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IMPACT OF THE FEDERAL TAX CODE ON RESOURCE RECOVERY

by

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The study assessed the extent to which a variety of federal tax subsidies to extractive industries affect the flow of materials to competing secondary materials industries. The impacts on virgin material supply for steel, paper, lead, copper, and aluminum industries were analyzed and flows of virgin and secondary materials characterized at points where they substitute as inputs to production. Econometric models were used to analyze the impacts on quantities of secondary materials recycled. It was estimated that the short-run effect of eliminating federal tax subsidies would increase the recycling of scrap steel by 0.42 percent; waste paper, 0.67 percent; lead, 0.75 percent; copper, 0.35 percent; and aluminum, 1.7 percent. The cumulative effect over the long-run from the elimination of the subsidies may be considerably larger if the impacts on investment and choice of technology decisions in the affected industries are included.

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ABSTRACT

This report assesses the extent to which a variety of federal tax subsidies to extractive industries affect the materials flow in competing secondary industries. The impacts of tax subsidies on virgin material supply curves for the steel, paper, lead, copper, and aluminum industries are analyzed in detail. The flows of virgin and secondary materials industries are characterized at points where the two materials substitute as inputs to production and consumption. Econometric models specified at these points of substitution are used to analyze the impacts of the tax subsidies on the quantities of secondary materials which are recycled. Within the limits of existing plant and equipment, we estimate that elimination of tax subsidies to virgin material industries would increase the flow of scrap steel by 0.42 percent, of wastepaper by 0.67 percent, of lead by 0.75 percent, of copper by 0.35 percent, and of aluminum by 1.7 percent. These estimates make no allowance for the long-run effects on investment which may arise from the subsidization of one of two competing industries. When investment effects and other federal policies (especially ICC regulation of freight rates, labeling requirements for scrap-based products, and the free access to minerals on federal lands) are also considered, the cumulative adverse impact on recycling may be far larger than the relatively modest effects measured in this report.

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CHAPTER 1

INTRODUCTION AND SUMMARY

Fears of future materials shortages and a concern for improving the quality of the environment have heightened public interest in recycling. Several major pieces of legislation contain statements to the effect that increased recycling should be a national goal. Despite efforts to define and establish a national materials policy, we have at present only a de facto policy which appears to favor use of virgin over secondary materials. Some aspects of this overall policy include:

(1) Taxation - as a consequence of depletion, expensing of exploration and development, capital gains, Domestic International Sales Corporation allowances, Western Hemisphere Trade Corporation allowances, and the foreign tax credit, investment in virgin material industries (either the purely extractive component, or in vertically integrated firms) is stimulated and product prices are lowered compared with results under neutral taxation.

(2) Freight Rates - railroad freight rates, which are controlled by the ICC, may be lower for virgin materials than for an equal volume of scrap.

(3) Labeling - several products derived from scrap materials are required to be so labeled. Rather than specify performance requirements alone, labels which are required to specify source discourage consumption by those who associate the words "recycled" or "waste" with inferior products.

(4) Others - federal procurement policies, at least in the past, have favored virgin materials over secondary sources. The mineral discovery system which gives away valuable

> mineral rights to stimulate exploration for virgin mineral supplies creates incentives favoring investments in virgin over scrap industries. Finally, the tax exempt status of municipal trash collection systems, combined with their financing out of general revenues rather than user charges, lowers the perceived cost of waste disposal and tends to stimulate greater waste production than would result if charges were based on use and reflected full social costs of disposal.

It has been alleged by many that national materials use is strongly biased toward the use of virgin raw materials over recycled or secodary materials and that a policy based upon a thorough analysis of social benefits and costs would favor more intensive use of recycled materials. Private incentives with respect to materials use may not reflect social desires for a variety of reasons. (1) Private profits are independent of social costs associated with the disposal of materials which are not recycled. (2) Environmental disruption associated with primary production is normally not a cost to primary producers. (3) The needs of future generations may receive too little attention if virgin material production is guided by current and projected prices rather than by an attempt to explicitly maximize intergenerational welfare.

This report is positive rather than normative or prescriptive. No attempt is made to determine or design the essential features of future federal materials policies. The intent of the report is to provide a comprehensive analysis of one element of the present de facto materials policy - the federal tax code - and its impact on virgin materials use and recycling in selected key industries including: paper, steel, copper, aluminum, and lead. Certain other policy elements, including federal mineral and timber policies, are also briefly reviewed.

Focusing as it does on one element of a complex national policy toward material use, the report must be accepted with caution. Though one element of the overall policy may not be of overwhelming import, taken collectively the various factors may have a highly significant impact on materials use.

This report is organized into eleven additional chapters and an appendix which trace virgin material tax subsidies through their historical development, analyze their present impact on corporate profits and market prices for outputs, and estimate the impact of the tax subsidies on recycling rates.

In Chapter 2 a central theme is developed: few if any of the arguments offered to justify the subsidization of mineral and timber industries are grounded in fundamental, widely-accepted economic criteria such as equity or efficiency. Mining and timber industries are among many which are accorded subsidization in the federal tax code. The significant tax subsidies to mining and timber operations are described in detail, both as to historical development and present magnitudes. An appendix to this report further delineates these historical developments.

Chapter 3 depicts the present pattern of industry taxation from a micro, or individual corporation point of view. Drawing from detailed corporate financial statistics in SEC Form 10-K reports, the magnitude of the tax burden in several industries is examined. Subsidies to mining, timber and paper companies result in lower effective tax rates on income. Paper companies have an income tax rate approximately 10 percent below general manufacturing; and mining companies pay about 30 percent less in taxes than a typical manufacturing firm would on identical income. This chapter also develops statistics on property tax rates for these industries.

The fourth chapter examines in detail a non-tax subsidy to mineral industries, the General Mining Law of 1872. Although the clear intent of the General Mining Law was to promote mineral exploration and development, inadequate provision for record keeping and inappropriate controls on excessive claim filing have unintentionally erected barriers to mineral development. This Law was analyzed because revision appears imminent - and all of the proposals for change involve the imposition of new taxes on mining.

The fifth chapter analyzes some of the indirect impacts of taxation on timber supplies through a detailed examination of timber resource allocation. Theoretically, taxation affects timber supplies directly as timber becomes more profitable than alternative land uses and indirectly through adjustments in the profit maximizing growth periods. Because the production function for timber is not well known, it is difficult to estimate the impact of timber tax subsidies on the supply of timber. Therefore, the analysis carried out in this chapter is largely theoretical in nature.

Chapter 6 contains estimates of the impact of various income tax subsidies on the price of certain virgin materials. Though final conclusions of market impact are unaffected by whether a tax is viewed as shifting supply or demand, the analysis here is simplified by assuming all effects are achieved through movement of the supply curve. The analysis of this chapter is biased toward taking an optimistic view of recycling potentials in that where assumptions must be made they err toward overstating the impact of tax subsidies in lowering virgin material prices.

Where taxes affect the cost of one factor of production (e.g., capital gains which affect the cost of capital), it is explicitly assumed that the change in relative factor prices will induce no substitution among inputs. This assumption makes it appear that by removing a tax subsidy to virgin timber production the full increase in the cost of capital will be realized and passed on in the form of higher supply prices. No provision is made for the possibility of substitution of the now cheaper labor, which profit maximizing corporations would be expected to do. When assumptions about the elasticity of the supply curve must be made, it is always assumed to be infinitely elastic, unless empirical estimates are available. Finally, in calculating the impact of the depletion allowance, corporate financial data were used where available, otherwise the maximum theoretically permitted by the tax code was used in place of the actual statistics.

Chapter 7 provides an overview of materials flows within the primary and secondary materials sectors with particular reference to points at which the two flows compete as inputs to production processes and as items of final consumption. We are especially interested in these points of substitution in calculating the impact of tax subsidization of one sector on materials flows within the other sector. The sources and uses of scrap materials are identified, setting the stage for econometric modeling of the materials flows of individual industries in the next five chapters.

In Chapters 8 through 12 we present analyses of the steel, paper, lead, copper, and aluminum industries. Using the discussion of materials flows as a framework for reference, we develop the background information for the econometric specification of intersectoral competition. The calculation of the impacts of tax subsidies to the virgin sector on the recycling of scrap materials could, in general, be performed in two ways.

In the first approach, which is admittedly short-run in nature, we used monthly data to estimate supply and demand curves for scrap materials, incorporating into the demand curve the price of both scrap and the competing virgin-based input. When the demand and supply curves are estimated with monthly data, we measure short-run responses to price changes holding the capital stock fixed. In the long-run, investment in new plant and equipment, which is influenced by relative input prices, would enhance considerably the possibilities for input substitution.

The second approach, which takes an optimistic long-run view, assumes that substitution between scrap and virgin inputs is perfect. In this model we need only the long-run supply curve for scrap materials to estimate the recycling impact. Where the data permitted, we estimated these supply curves with annual data in order to capture the effects of investment decisions on supply.

This research may be viewed as an extension of a 1974 study performed by Booz Allen and Hamilton, Inc. for the Environmental Protection Agency entitled, "An Evaluation of the Impact of Discriminatory Taxation on the Use of Primary and Secondary Raw Materials." That study outlined the various tax subsidies to virgin material production and derived maximum price impacts in much the same fashion that we did in Chapters 2 through 6. The use of econometric techniques in the present study to estimate the potential effect of these price impacts on recycling differs substantially from the interview methodology employed by previous researchers. In addition to statistical biases which would be present in any responses, the interview approach suffered because industry representatives were generally unwilling or unable to supply the requested estimates.

Chapter 13 contains a summary of the research results and a discussion of the strengths and weaknesses of the statistical approach which was used. This section also contains a brief outline of suggested extensions of the present study.

CHAPTER 2

TAX SUBSIDIES FOR MINERAL AND TIMBER INDUSTRIES

Over the years federal subsidization of various segments of the economy has become so familiar and ubiquitous that one is hard pressed to name a single unaffected activity. An almost endless list of federal subsidies include: the granting of free land to homesteaders (in the Western States in the 19th century, but in blighted urban areas now), the granting of mineral rights to individuals making valuable discoveries, sponsorship of research in social and physical sciences, and reductions in income tax liabilities for favored groups. The latter subsidy is especially significant; tax subsidies to industry are estimated to exceed $10 billion (see Table 2-1) and further deductions are given to homeowners, the elderly, the blind, families with children, and so forth.

A partial listing of estimated 1976 income tax subsidies for business firms is contained in Table 2-1. Of particular relevance to this report are the first four subsidies: expensing of mineral exploration and development costs - $950 million; excess of percentage over cost depletion - $2,200 million; capital gains treatment of iron ore and coal royalties - $5 million; and capital gains treatment of timber - $145 million. Since 1969, expensing has increased almost three fold and percentage depletion has increased by one half, but the other two categories show almost no change. Because the expensing and percent depletion figures contain deductions for the oil industry, it is desirable to separate that component attributable to non-fuel minerals. Expensing of exploration and development for non-fuel minerals has been assumed by the Treasury (perhaps incorrectly) to be negligible.

Table 2-1. ESTIMATED 1975 INCOME TAX SUBSIDIES
(Partial Listing)

	Millions of Dollars
Natural Resources, Environment and Energy:	
Expensing of exploration and development costs (oil and gas only)	950
Excess of percentage over cost depletion	2,200
Capital gain treatment of iron ore and coal royalties	5
Timber: capital gain treatment	145
Pollution control: 5-year amortization	30
International Affairs:	
Exclusion of dividends of LDC corporations	55
Domestic International Sales Corporations	1,070
Western Hemisphere Trade Corporations	50
Agriculture:	
Expensing of capital outlays	145
Capital gain treatment of certain income	20
Commerce and Transportation:	
Surtax exemption	3,590
Tax deferral for shipping companies	35
Railroad rolling stock amortization	60
Bad debt reserve for financial institutions in excess of actual losses	1,030
Business Investment:	
Depreciation on rental housing in excess of straight line	115
Depreciation on buildings in excess of straight line	280
Expensing of research and development	630
Capital gain (other than farming and timber)	595
Investment credit	4,160

Source: The Budget for Fiscal Year 1976, U.S.G.P.O., P.108-109

In this chapter the historical development of the taxation of mineral and timber industries is reviewed with an emphasis on the rationale or motivation for a favored status. A more comprehensive, supporting document to the views expressed in this section is contained in Appendix A. This appendix contains numerous verbatim quotes and analyses offered by those in Congress and in the mining industry at the time when the tax policy toward mineral industries was being promulgated. Following the historical review is an economic analysis of the arguments for and against subsidization of selected industries.

I. MINERAL TAXATION POLICY

A. History

The 1913 legislation for the first income tax contained provisions for the recovery of capital assets through depreciation deductions against taxable income. In recognition of the eventual exhaustion of producing mineral reserves, owners of such properties were permitted a deduction of five percent of the value of mineral production, the sum of deductions to be limited to total investment. A subsequent revenue act three years later introduced the term "depletion" and limited the total deduction to (1) the invested capital for those mines acquired after 1913, or (2) the 1913 value for mines acquired prior to 1913. This limit on the total deduction was repealed in part in the Revenue Act of 1918 when the concept of "discovery depletion" was introduced. Under this system the depletion allowance for newly discovered minerals was based on fair market value to be determined within 30 days of discovery. Discovery depletion marked the first major departure from an asset recovery system limited to cost to one based on value. At that time it was argued that permitting the taxpayer a total depletion deduction equal to "discovery" value as opposed to a deduction based on acquisition cost, would stimulate mineral exploration by providing a tax break for newly discovered mines. The benefit would lie in exempting from future taxation an amount of ordinary income equal to the "discovery" value minus the acquisition cost.

Discovery depletion established tax equity between income from mines developed before 1913 for which depletion, based on 1913 value, often exceeded actual cost, and income from mines developed after 1913 for which depletion had been limited to the investment. Although it may be argued that Congress should not permit a mine owner to deduct more than the total investment in the mine, it must be recognized that other costs associated with gaining ownership of the mine (primarily exploration activities to locate replacement mines) were only recovered gradually through addition to the adjusted basis. A provision to allow the value of the discovery to determine the amount of capital to be recovered would compensate for the delayed recovery of prospecting and developmental costs.

Aside from whether discovery depletion actually encouraged mineral exploration it developed two major problems. The first occurred when mineral prices dropped in 1921. Total allowable deductions were still based on the originally established discovery value and not 1921 market value. Concern that depletion deductions would be used to offset income from other sources, and mine owners would end up paying no taxes, prompted Congress to limit maximum deductions to the amount of net taxable income derived from the newly discovered mine. This provision, later amended to limit deductions to 50 percent of the net taxable income to ensure that all mine owners would pay some taxes, has remained in effect to the present time.

The second problem of discovery depletion involved the difficulty of estimating the extent of newly discovered minerals (especially oil and gas), defining a new well or mine, and assigning a reasonably fair market value to the property. Geological measuring procedures were unreliable, and there were no guidelines for determining fair market value. Inevitably, many new oil wells and mines were inaccurately valued by the Treasury. Not only was it extremely difficult to establish discovery values on the basis of incomplete information, but administration of the law was complicated by frequent litigation over the appropriateness of Treasury determined values. A Senate Select Committee was created in 1924 to investigate allegations of abuses under the law and to devise methods of improving the capital recovery process. The Committee report suggested that future depletion be based on normal or average experience under the discovery depletion provision. Actual profits on a sample of mineral properties would be discounted back to establish a value as of the date of discovery. Depletion was to be computed as a percent of the value of mineral output which would result in recovery of the total value of the mineral discovery.

The Internal Revenue Act of 1926 permitted percent depletion of 27½ percent of the gross revenue from oil and gas because valuation problems under discovery depletion had been the most pronounced. Discovery depletion accounted for over 86 percent of the depletion deductions taken by the petroleum industry in the early 20's, giving rise to considerable confusion in the administration of the petroleum depletion allowance. In contrast, other mineral industries - especially those of the more commonly found minerals - made relatively little use of discovery depletion because most mines had been discovered before 1913. However, the mineral industries anticipated substantial after-tax savings if percentage depletion were available as an option.

Metal industry spokesmen argued that percentage depletion would simplify their depletion procedures, a necessary reform. Moreover, it was argued, their extraction processes were similar to petroleum, and equity required that similar industries be taxed in a similar manner. The mining industries requested a flat rate percentage depletion allowance which approximated the average depletion deductions taken in the past. Some argued that they needed a tax break in order to stimulate exploration and production, or to overcome the depressed state of their industry. It was also estimated that the switch to percentage depletion would result in no loss of tax revenue. In 1932 Congress began extending percentage depletion to the metal industries in spite of the Roosevelt Adminstration's objections that the depletion allowances permitted the taxpayer to recover far more than the full capital investment.

In the 1932 Act the owner of the mineral deposit was forced to make a binding decision between cost and percentage depletion. A failure to elect meant the loss of any rights to percent depletion. Although this restriction was eliminated in 1942, an owner today still must choose between cost and percent depletion. The list of minerals covered by percent depletion gradually expanded; many hardrock metallic minerals were added in the 1930's, several non-metallic minerals were included during World War II, and by 1954 Congress decided to include all minerals (including sea shells), except those from inexhaustible sources such as the air.

In 1969 percent depletion rates on all minerals were limited to a maximum of 22 percent; this entailed a reduction for oil and gas from the previous 27½ percent rate, and for many metallic minerals from a previous rate of 23 percent. In 1975 the percent depletion deduction for large oil and gas operators was eliminated. For smaller operators it was set at 22 percent until 1980, and scheduled to be gradually phased down.

Percent depletion represented an administrative improvement over discovery depletion; calculations were immensely simplified and subsequent litigation was essentially limited to determinations of who was entitled to depletion and at what stage in mineral processing was value to be determined. Basing the rates of percent depletion on historical data under the discovery depletion regulations, there was at least the intent that depletion would permit full recovery of the capital value of a mine.

At about the same time Congress was establishing capital recovery provisions for the mineral industries through cost and discovery depletion, other significant features for capital recovery were also being developed. In 1917 oil and gas operations were permitted to expense incidental drilling costs by deducting them against taxable income. In 1921 mine owners were granted similar expensing privileges for development expenditures.

Neither industry had the opportunity to expense outlays for mineral exploration.

In 1918 Congress attempted to prevent "double taxation" of income earned abroad by establishing a credit for foreign taxes paid against U.S., tax liability. A more detailed economic analysis of the Foreign Tax Credit is reserved for later in this chapter, and the legislative history of the Credit is reviewed in Appendix B.

In 1951 Congress substantially changed the treatment of mineral exploration expenditures (excluding those for oil and gas) by allowing them to be expensed through immediate deduction against taxable income. Initial limits on exploration deductions were eliminated in 1969, with the stipulation that, although expensable, exploration costs were subject to recapture through a corresponding reduction in allowable depletion deductions if and when a mine reached the producing stage.

When provisions for expensing mineral development outlays were enacted in 1921, Congress departed significantly from the concept that capital recovery be spread over the life of the asset in approximate proportion to the incremental losses in value. Developmental activities for access tunnels, site preparation, geophysical assays, and the like are analogous to the development and construction of buildings and machines for a planned manufacturing operation. In manufacturing such expenses are recovered gradually through depreciation deductions. Immediate recovery of mineral development costs which enhance the value of the mine over its entire life mismatches the timing of deductions with the actual decline in the value of the asset.

Another principle of capital asset recovery, that the total deductions equal the actual decline in asset value, was not violated when development costs became deductible. Discovery depletion permitted value as of the date of discovery to be recovered. Subsequent developmental costs had previously been capitalized and depreciated. In 1921 development costs became immediately expensable against income; the only violation of the general principle of capital asset recovery was the mismatching of costs and deductions.

The substitution of percent depletion for discovery depletion did not necessarily result in a violation of capital asset recovery principles. If the sum of percent depletion deductions actually matched the full costs of discovering the mine, total deduction would match total costs. Of course, there was no longer any guarantee that the two figures for a given property would bear any close resemblance; capital costs could easily be more than fully recovered.

When exploration outlays also became expensable in 1951 the capital recovery principle was totally violated. Now the mining firm could deduct immediately the costs associated with prospecting for new properties. While this provision is laudable in that it closely matches deductions with costs, it enables discovery costs to be recovered more than once. Exploration costs up to a limit of $100,000 per year and limit of $400,000 over any four year period were immediately recoverable. For those firms using cost depletion for asset recovery, exploration costs in excess of these limits could be recovered gradually through depletion deductions. If a mining firm can deduct costs associated with making the discovery, the recovery of asset value through percent depletion is redundant. Firms were recovering some of the same costs twice. The relative impact of the "double deduction" was greatest for exploration outlays that remained under the statutory limit.

The 1969 Act eliminated any quantity limits on exploration deductions and substituted the new restriction that deductions on a property by property basis were subject to recapture if and when production commenced. Since the percent of all exploration outlays resulting in valuable discoveries is unknown, the amounts likely to be eventually recaptured are unpredictable. It has been suggested by mining industry spokesmen (Edwards cited in

Chapter 4)[1] that the odds against a mining claim turning into a profitable, producing mine may be as great as 10,000 to 1, but exploratory activity may also be highly concentrated on the better prospects. The fraction recaptured certainly would be more than .01 percent.

The net result of the 1969 Act was to permit double recovery of exploration costs up to the $400,000 limit, except for that fraction resulting in productive properties. And even on the latter fraction the deduction was recaptured without any interest penalty; in effect this gave the corporation an interest free loan until it was recaptured.

B. Miscellaneous Taxes and Subsidies

Although percent depletion and expensing of exploration and development are by far the most important elements distinguishing federal taxation mineral industries from corporations in general, several other provisions of state and federal policy deserve note. For many years some states have levied severance taxes on certain mineral outputs. More recently, the Federal Government established income tax deductions for corporations engaged in trade in the Western Hemisphere (WHTC) or engaged primarily in export trade (DISC).

(1) Severance Taxes-

Severance taxes, levied on either the quantity or value of output, are essentially excise taxes on mineral output. In an accounting sense, and in terms of economic incentives, severance taxes function exactly opposite to percent depletion deductions (See Chapter 6). It can also be shown that severance taxes act as an incentive to delay production - (See Peterson, among others) because the present value of profits from a mine (or forest) is not decreased, and is usually increased by postponing production when severance taxes are imposed. For this reason severance taxes are popular with conservationists.

Severance taxes are indistinguishable from production royalties. The regional pattern of severance taxation strongly suggests that those states having the highest grade, most easily mined deposits also tend to have the highest severance taxes. Apparently severance taxes are viewed by states as a means of taxing economic rents accruing to the more profitable mineral deposits. Recently, Congress has considered the desirability of national severance taxes on mineral output. Some of the specific proposals are discussed in greater length in Chapter 4.

(2) Western Hemisphere Trade Corporations (WHTC)-

Since 1954, a United States corporation which controls a foreign based enterprise, such as a mining operation, can be organized as a WHTC. In order to qualify, the corporation must conduct its entire business (aside from incidental purchases) in North, South, and Central America, and the West Indies. Two further requirements are (1) 95 percent of the gross income for the current tax year and the two preceding tax years must be derived from sources outside of the U.S., and (2) 90 percent of such gross income must be derived from the active conduct of a trade or business.

WHTC's are commonly a subsidiary of an American parent corporation. The advantage of operating a WHTC is that approximately one-third of the WHTC's taxable income is deductable before tax. This special deduction is computed by multiplying the WHTC's taxable income by a fraction whose numerator is 14 percent, and whose denominator is the ordinary corporate tax rate. An additional feature of WHTC's is that corporate shareholders, most importantly the parent company, are not taxed on dividends earned but not yet received. Even when the dividends are distributed, the parent company is exempt from taxation on 85 percent to 100 percent of the dividends received.

(3) Domestic International Sales Corporation (DISC)-

Pursuant to a 1971 law designed to improve the United States' balance of trade, American corporations engaged in exporting domestically produced goods are allowed to form a DISC. To qualify for DISC tax treatment, the corporation must derive 95 percent of its gross income from the exportation of goods to foreign countries.

DISC's are typically a subsidiary of a parent corporation engaged in producing the exported good. The DISC itself is not subject to the usual corporate income tax. Instead, the shareholders are taxed (at normal rates) on 50 percent of the earnings for each tax year whether distributed or not. The remaining 50 percent is taxed when distributed or when the shareholder sells, or otherwise disposes of, his shares.

Mining and timber companies were originally entitled to form DISC units, but the recent Tax Reduction Act of 1975 virtually eliminated this option for mining and timber. At present, a corporation engaged in exporting minerals (including timber) which enjoys a cost depletion or percentage depletion allowance can qualify as a DISC only if more than 50 percent of the value of the exported product is due to manufacturing processes exclusive of extraction, storage, transportation, and other similar costs.

C. Economic Analysis of Income Tax Subsidies for Mining

Although concurring that income from mining is taxed preferentially compared with general manufacturing, McDonald[2] has advanced theoretically based arguments in support of continued income tax subsidies to mineral industries. Other economists, in particular Musgrave,[3] have strenuously disputed both the assumptions and the theoretical approaches used to justify subsidization of mining. Subsidy arguments have been based on risk, capital intensity, and neutrality with respect to the taxation of foreign income.

(1) Subsidization through Foreign Tax Credit-

According to Musgrave the present U.S. approach to the taxation of foreign income attempts to incorporate several principles.[4] The resident principle dictates that the Treasury tax the world income of U.S. individuals and U.S. corporations, except for unremitted profits in foreign subsidiaries. The source of income principle allows a foreign country to tax the income generated within its borders. Finally the principle of capital export neutrality requires that taxes should not affect the allocation of U.S. investment funds between countries.

The foreign tax credit represents an attempt to establish capital export neutrality by making the net total of all taxes paid per dollar of income identical, irrespective of the source of income. Domestic taxpayers may credit most foreign income taxes against domestic tax liability of foreign, but not domestic income. Capital export neutrality is essentially a world efficiency proposition; identical taxes irrespective of source of income will allow investment to flow throughout the world to where the return to investment is greatest. If higher after tax returns can be earned on foreign rather than domestic investments, U.S. welfare is increased by adopting a neutral stance with respect to income taxation.

An alternative view that foreign taxes merely represent a cost of doing business, and should be deducted from foreign income before domestic tax liability is computed, has some merit. In the recent past many oil royalty payments were thinly disguised as income taxes to qualify them for the foreign tax credit. This represents a violation of the intent of the principle of capital export neutrality; as Jenkins and Wright have demonstrated, net of tax rates of return to foreign oil operations have been unusually high.[5] Allowing foreign oil royalties to be treated as taxes has increased the differential in rates of return to oil investments rather than promoted capital export neutrality.

(2) Subsidies for Risk-

Central to the use of risk as an argument for tax subsidization is the notion that, because risks for individual firms engaged in mining are far greater than societal risks in mining, the supply of capital to the mining industry is undesirably low. The development of insurance markets is one mechanism through which the investment distorting elements of individual risk can be reduced. Although the use of insurance to guarantee rewards to prospecting would probably be counterproductive because the element of risk is an important factor motivating certain individuals, there are other mechanisms for pooling of risks. The collectivization of risk through the aggregation of risk bearing units is a dominant theme in the history of the organizational structure of mining. The merger of several smaller operations into one parent corporation should reduce perceived risk in the financial community and thus lower capital costs. Lower capital costs continued to act as an impetus to further concentration in the mining industry.

If subsidies for risk in mining are to be given, they would be most productive directed to the smaller operators who face inelastic capital supplies because of perceived risk in small operations.

(3) Taxation and Economic Efficiency-

In a series of papers Harberger has persuasively developed the argument that differentials in income tax rates across industries create a distortion in investment allocations and a corresponding loss in economic welfare.[6,7] It is assumed that private investment decisions are guided by returns net of taxes. In this analysis existing differentials in the rates of taxation of income stimulate more investment in lightly taxed activities such as mining, timber, home ownership, and farming, and less in the more heavily taxed manufacturing sector, than would occur under a system of uniform income tax rates across industries.

Harberger's entire analysis has centered on economic efficiency in the market for capital as a factor of production. Societal returns to investments include tax receipts on earned income as well as the net of tax returns (after adjustment for risk and degree of concentration in an industry). Because excessive investment in lightly taxed industries lowers the pretax rate of return, greater societal returns to investment would occur if funds could be removed from low tax activities and placed in industries subject to greater income tax burdens.

A related series of exchanges concerns the impact of income taxes in the product market. If taxes are to be non-distorting they should raise the price of all products by the same percent. McDonald observed that if income taxes are shifted forward onto final products, an income tax on capital would shift final output prices by the largest percentages in those industries having the greatest capital intensity (i.e., petroleum and metal mining). While acknowledging the validity of McDonald's argument, Musgrave noted that allocative efficiency is not the only criterion which should be considered. Equity must also be taken into account. Musgrave draws an interesting analogy to the personal sector of the economy. In the personal sector the most allocatively efficient tax would be a head tax. Obviously, it is impossible to attain this neutrality, due to considerations of equity.

McDonald's argument does offer some grounds for support of preferential taxation of capital intensive sectors of the economy. But in seeking allocative efficiency in the product market, the Harberger type of efficiency is introduced in the allocation of capital resources in the market for factors of production. McDonald shows that, in general, it is impossible to achieve efficiency in both markets simultaneously.

II. TIMBER TAXATION POLICY

A. History

The segregation of long-term capital gains from ordinary income for tax purposes was introduced in the Revenue Act of 1922. At that time, it was felt that the taxation of capital gains at ordinary income tax rates discouraged individual taxpayers from selling their farms, mineral properties, and other capital assets. Whereas maximum ordinary income tax rates for individuals was 40 percent under the 1922 Act, the maximum rate of capital gains for individuals was limited to 12.5 percent.

Prior to 1944, the definition of capital assets afforded capital gains tax treatment to only those timber owners who made an outright sale of standing timber, providing that the timber had been held for more than six months prior to the year in which it was cut. A further requirement was that the timber could not have been held by the owner for sale to customers in the ordinary course of business. Therefore, if a timber owner disposed of his timber in the course of his business, he was required to pay ordinary income tax rates on the profits from the sale. Similarly, a timber owner who cut his own timber for use in his own sawmill was also subject to ordinary income tax rates on the increased value of the timber when cut.

In 1944, the timber industry petitioned Congress for preferential tax treatment that, they argued, would promote equity between taxpaying timber owners, and promote conservation. Congress subsequently enacted Section 117(k) of the Internal Revenue Code - presently Section 631 - which extended capital gains and loss status to virtually all timber income. Specifically, capital gains tax treatment was granted to taxpayers who own timber and cut it, and also to timber owners who dispose of their timber under a cutting contract. The significance of this action was that owners of standing timber could cut it, or have it cut, and the profits would be taxed at the capital gains rates. Furthermore, no distinction was drawn between timber that was cut for sale or for use in the owner's business.

There has been little change in the timber tax subsidy since 1944. The House of Representatives unsuccessfully attempted in 1954 to prohibit the current expensing of certain costs allowable to timber not cut during the tax year, but the Senate (and final) version of the Internal Revenue Code of 1954 adopted one of the expensing provisions. In 1963, the

Kennedy Administration proposed (1) classifying all timber income as ordinary income (with some exceptions) and (2) allowing current expensing of reforestation costs. The proposals were rejected by the House in favor of placing timber income in the higher tax bracket of a two-tier capital gains classification system. As in 1954, the Senate adopted neither plan, and consequently, the Revenue Act of 1964 left the timber tax subsidy basically intact. There were no specific actions regarding timber in the Tax Reform Act of 1969, but the increase in capital gains tax rates to 30 percent for corporations also applied to the timber industry.

B. Capital Gains Theory

Many economists draw a distinction between "ordinary income" and "capital gains." Generally speaking, capital gains is that income which results from appreciation in value of a capital asset, and ordinary income is income from all other sources. It is sometimes pointed out that ordinary income is planned for, meaning that a person allocates his scarce resources in a manner so as to obtain this income. Capital gains, on the other hand, are unforeseen increases in the real value of one's assets, not directly attributable to one's efforts, intelligence, or risk taking (Seltzer). The purpose and intent of holding an asset supplies an additional basis for differentiation (Smith). Capital gains are held for investment, whereas ordinary income is used to replenish stock and inventory.

These differences are easily illustrated in a simple agricultural society where the annual crop is the basis of taxable income. If the harvest is particularly good in any given year due to unusually favorable weather, the excess over that needed for consumption will be used by the prudent farmer as seed to increase the next year's planting. This increase in the amount of seed available for planting is viewed as a capital gain, and the portion of the harvest which is to be consumed is the equivalent of ordinary income.

There are two major theoretical issues with respect to the taxation of capital gains. The first is: Given the nature of capital gains, is it fair to tax them? Those who favor taxation feel that it is most equitable to define taxable income as "total accretion," or more specifically, consumption plus the change in one's net worth (Musgrave). In this view, even though capital gains are not national income (i.e., production), they are still personal and spendable income which increases one's economic power in the sense of directing the allocation of resources, whether in the form of consumption or investment. Those who argue against capital gains taxation contend that capital gains are an accretion to capital which in turn produces taxable income. Aside from the merits of these arguments, the issue as a practical matter is largely moot because the United States, contrary to many other countries, has always taxed capital gains.

The second major issue is: What is the effect of a capital gains tax upon capital resource allocation? From an efficiency standpoint, a tax should not alter the flow of capital asset sales and purchases that would arise in a perfectly functioning market. However, when a tax is levied upon the increased value of a capital asset at realization (conversion to cash), the tax has a tendency to discourage the conversion of the asset into cash during any given tax year. This undesirable effect of the tax reduces the efficiency of capital resource allocation in the economy because capital assets are being held by people who do not make the most efficient use of them.

In view of the problems raised by the equity and capital resource allocation issues, the United States has adopted a compromise policy of taxing capital gains at rates lower than the ordinary income tax rates.

C. Timber and Capital Gains Theory

Timber is difficult to place within the capital gains framework previously developed. "Tree farming" (Mead) is a production process in which land is used to grow trees, and the trees in turn manufacture wood fiber; wood is both the factory and the product. Affording timber income the status of capital gains implies that the annual joint product of land and trees (wood fiber) is transformed into a capital asset. However, the income derived from timber is readily broken down into two components: (1) real income in the national accounting sense from the production of wood fiber, and (2) income from increases in the price of standing timber. Transposed into terms, the former is identified with ordinary income taxed at the normal rate, and the latter is a traditional capital gain taxed at more favorable rates. Although the two components are easily conceptualized it is virtually impossible to assess their magnitudes for tax purposes in any given tract of timber. Consequently, it may be argued that since the annual accretion in value of a timber tract is primarily a result of the production function of trees, tree farming is more appropriately viewed as ordinary production, distinguished from other agricultural production primarily on the basis of a longer growth-to-maturity cycle, and should therefore be taxed as ordinary income and not as a capital gain. Voicing a dissenting view, representatives of the timber industry (particularly Wissing and Condrell) have argued that the long growing periods for timber entail unusual risks and, accordingly, the accretion in the value of standing timber should be taxed preferentially.

CHAPTER 2
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CHAPTER 3

THE EXTENT OF PREFERENTIAL TAXATION IN MINING AND TIMBER INDUSTRIES

In this chapter the magnitude of the tax burden is examined for a sample of mining, timber, paper, and manufacturing companies. There is, to our knowledge, no published summary of this information which incorporates both tax benefits from preferential taxation, as well as possibly adverse effects from property and severance taxes. The Securities and Exchange Commission requested that corporations report any expense constituting more than 1 percent of revenues as supplementary information to the income statement, beginning with 1973 10K reports. This data provides the basis for an analysis of the differential rates of taxation on income from capital across industries.

In his study of income taxation by industry group, Rosenberg was unable to obtain a detailed breakdown of many of the taxes, especially property and severance taxes.[1] Assuming property tax rates are nearly uniform across industries, Rosenberg concluded that mining companies may pay nearly 80 percent of pre-tax income in various taxes, in contrast to an effective tax rate of less than 50 percent for manufacturing. (Rosenberg used the average property tax rate in manufacturing, and multiplied by net assets in mining to obtain property tax estimates for mining companies.) It would be incorrect to assert that mining companies receive preferential tax treatment if their total bill is really of this magnitude. The Rosenberg results should not be accepted without further inquiry, however, for the estimate of property taxes may be inaccurate to the extent that assets in mining are taxed differentially from those in manufacturing.

Two views of property taxation produce contradictory predictions as to the effective tax rate for property in mining and timber production, vis-a-vis manufacturing. One position holds that since a mine is immobile, even in the long run, there is a tendency for property tax rates to be higher than on more mobile capital in manufacturing. The taxation authority need not fear that capital will flee to a lower tax district, if the capital is tied to production from a mineral deposit that continues to earn economic rents. The contrary view is that property tax rates in mining and timber production would be lower than in manufacturing because of the dominance of mining and timber firms in local economics and their consequent bargaining power to obtain preferential tax treatment.

Table 3-1 presents property taxes as a percent of net assets in plant, property and equipment for major corporations in the timber, paper and mining industries, as well as for a randomly selected group of large manufacturing concerns. Property tax rates for mining averaged 1.71 percent, for paper 2.16 percent, for timber 2.39 percent, and for manufacturing 2.73 percent. The latter figure compares with a figure of 1.79 percent for manufacturing used in the earlier Rosenberg study. Property tax rates have generally increased in the past decade and that alone could well explain the difference between the two estimates for manufacturing.

Several pieces of information suggest that the calculated property tax rates over-estimate the effective tax rate. Timber and paper companies carry timber lands at acquisition cost which is often far below current market value. For example, Pacific Lumber values its timber lands at $25 an acre in its balance sheet yet recently sold several thousand acres for $1500 an acre. Were assets to be valued at current market value the tax rate for the forest product industry would certainly decline substantially.

Table 3-1. PROPERTY TAX RATES FOR VARIOUS INDUSTRIES (1973 data)

Integrated Forest Products:	
Georgia Pacific	1.50%
Boise Cascade	2.62
Weyerhaeuser	2,99
Southwest Forest Industries	2.10
Potlach	1.65
Pacific Lumber	4.96
Pope and Talbot	2.24
Bohemia	2.13
Champion International	1.76
Louisiana Pacific	1,90
Average	2.39
Paper:	
St. Regis Paper	2.24
International Paper	2.26
Westvaco	1.12
Scott Paper	2.26
Kimberly Clark	1.73
Union Camp	1.19
Great Northern Nekoosa	2.05
Crown Zellerbach	2.72
Longview Fibre	3.88
Average	2.16
Mining:	
American Smelting Refining	3.00
AMAX	.71
Diamond Crystal Salt	2.28
Foote Mineral	2.02
Freeport Minerals	1.85
Kennecott Copper	1.34
Phelps Dodge	1.53
Pittston	1.68
Westmoreland Coal	.96
Average	1.71

Table 3-1 (continued). PROPERTY TAX RATES FOR VARIOUS INDUSTRIES

Metal Mining and Fabricating:	
Aluminum Corp. of America	1.34%
Bethlehem Steel	2.10
Republic Steel	2.69
Reynolds Metals	1.35
Average	1.87
Manufacturing:	
DuPont	3.18
American Home Products	2.92
Copperweld	3.12
Fort Howard Paper	2.24
Corning Glass Works	2.90
Dow Jones	3.23
General Mills	3.06
General Tire and Rubber	3.00
Goodyear Tire and Rubber	1.58
Westinghouse Electric	2.09
Average	2.73
Petroleum:	
Texaco	.85
Std. Oil Ohio	.84
Shell Oil	1.62
Atlantic Richfield	1.75
Average	1.27

Source: Derived from Corporation 10-K Reports.

ALTERNATIVE MEASURES OF THE TAX BURDEN

Depending upon one's definition of efficiency various measures of the tax burden can be established. Several ratios of taxes to income indicate an effective rate of taxation, and each ratio is calculated by using a slightly different view of efficiency. It is well recognized by economists that if tax rates differ across industries, there will be incentives for excessive investment in the low tax industries, and insufficient investment in the high tax industries.[2,3,4,5] In order to maximize the aggregate return on capital (assuming diminishing returns in each industry) one would invest in each industry until the rate of return to capital was equalized in all industries. In a world with no income taxes and a competitive form of organization, this result would be anticipated. Income taxes lower the net return to capital enjoyed by investors, and capital would tend to flow so as to equalize the after tax rate of return in each industry. If tax rates differ across industries, the allocation of capital is distorted from the allocation which maximizes the gross of tax returns (which are the actual returns to society - equalling profits plus taxes).

The national efficiency argument posits that investment should take place so as to equalize gross of tax returns domestically. Consequently it measures the rate of taxation on income after all foreign taxes have been paid.

Another measure of tax burden is that employed by the corporations in their 10-K reports to the Securities and Exchange Commission (SEC). In this report a reconciliation of tax rates is given; it explains why the "effective" tax rate, which is obtained by dividing the total of foreign, state, and federal income tax payments by pre-tax income, differed from the statutory 48 percent.

The world efficiency point of view is that the gross of tax returns should be equalized for all corporations, no matter where the income is earned. Clearly this view may be contrary to the interests of individual countries - this country would receive little direct benefit from foreign investments which are taxed at nearly 100 percent even though worldwide welfare may be enhanced by exceptional gross of tax returns. Multinational corporations, in arguing for retention of their current tax status, typically offer their total tax bill as evidence of a large tax burden relative to purely domestic corporations.

A commonly held view of taxation equity demands that realized Federal income tax rates be brought into approximate equality across industries. While the first three measures of tax burden may include all taxes (property, severance, and franchise, as well as all forms of income taxes), this view holds that only federal income tax payments should be included in the computation of the tax burden. This position has been espoused by Representative Vanik in arguing for a closure of tax "loopholes" enjoyed by multinational firms.[6]

Tables 3-2 through 3-6 portray rates of taxation of income from capital, as calculated by the four alternative methods previously discussed, for various industries including integrated forest products, pulp and paper, metal mining, integrated metal mining and fabrication, and a sample of manufacturing firms. By most measures the timber, paper, and mining firms enjoy preferential tax treatment relative to the sample of manufacturing firms. The average effective tax rate for each industry, as reported to the SEC, was 40.7 for forest products, 40.6 for pulp and paper, 25.5 for metal mining, 37.1 for metal mining and fabricating, and 45.9 for manufacturing.

In each industry group the principal sources of preferential taxation are delineated in a reconciliation. For the integrated forest products industry capital gains treatment of income is the most important

Formulas

$$\text{Domestic efficiency} = \frac{f + s + p + x + m}{y + p + x + m} \quad (1)$$

$$\text{SEC's effective rate} = \frac{f + s + g}{y} \quad (2)$$

$$\text{World efficiency} = \frac{f + s + g + p + x + m}{y + p + x + m} \quad (3)$$

$$\text{Federal Income Tax Rate} = \frac{f}{y - s - g} \quad (4)$$

where: y = income before taxes on income

f = federal income taxes

s = state income taxes

g = foreign income tax

p = property taxes

x = severance taxes

m = franchise taxes and other taxes

Table 3-2. TAXATION OF INTEGRATED FOREST PRODUCTS INDUSTRY

Tax Burden

Firm	Domestic Efficiency	Effective Rate Reported to SEC	World Efficiency	Federal Income Tax Rate
Bohemia	45.7%	43.5%	45.7%	40.5%
Champion Int'l	43.0	42.1	47.8	32.3
Georgia Pacific	45.2	41.	42.5	34.2
Louisiana Pac.	44.2	42.	44.2	+
Pacific Lumber	55.8	43.4	55.8	46.9
Pope & Talbot	30.0	43.3	44.4	27.8
Potlach	43.1	36.	43.1	27.3
S.W. Forest Ind.	47.7	42.6	47.7	36.6
Weyerhaeuser	53.4	32.	50.8	43.9
Average	45.3	40.7	46.9	36.2

Reconciliation

Firm	% Taxed at Capital Gains Rate	Reduction in Effective Rate from Capital Gains	Investment Tax Credit
Bohemia	43	7.7	2.2
Champion Int'l	29	5.3	2.5
Georgia Pacific	39	7	1
Louisiana Pac.	50	9	0
Pacific Lumber	53	9.5	0
Pope & Talbot	27	4.9	0
Potlach	86	15.4	3.8
S.W. Forest Ind.	27	4.9	3.3
Weyerhaeuser	78	14.	1
Average	48	8.6	

+ denotes unavailable
Source: Derived from Corporation 10-K Reports.

Table 3-3. TAXATION OF THE PULP AND PAPER INDUSTRY

Tax Burden

Firm	Domestic Efficiency	Effective Rate Reported to SEC	World Efficiency	Federal Income Tax Rate
Crown Zellerbach	34.1	37.1	44.9	21.3
Great Northern Nekoosa	51.6	45.4	51.6	40.2
Kimberly Clark	33.5	46.7	49.2	27.2
International Paper	37.7	35.	43.3	31.4
Longview Fibre	43.5	38.9	43.5	38.9
St. Regis Paper	41.3	37.	52.7	40.3
Scott Paper	39.2	35.	44.3	28.1
Union Camp	46.6	44.0	46.6	+
Westvaco	47.6	46.1	48.6	42.5
Average	41.7	40.6	47.2	33.7

Reconciliation

Firm	% Taxed at Capital Gains Rate	Reduction in Effective Rate from Capital Gains	Investment Tax Credit
Crown Zellerbach	67	12.1	-
Great Northern Nekoosa	18	3.2	-
Kimberly Clark	11	2.	-
International Paper	40	7.2	2.2
Longview Fibre	44	8.	1.
St. Regis Paper	44	8.	3.
Scott Paper	89	16.	-
Union Camp	12	2.2	2.2
Westvaco	-	-	1.7
Average	36	6.5	

+ denotes unavailable

- denotes negligible

Source: Derived from Corporation 10-K Reports.

Note: Data on Mead Corp. excluded because 10-K Report did not contain relevant data.

Table 3-4. TAXATION OF THE MINING INDUSTRY

Tax Burden

Firm	Domestic Efficiency	Effective Rate Reported to SEC	World Efficiency	Federal Income Tax Rate
AMAX	25.6	28.8	37.4	20.1
Am. Smelting and Ref.	25.6	17.2	29.6	13.0
Anaconda	32.6	24.	36.3	18.6
Diamond Crystal Salt	32.8	42.6	33.8	29.0
Foote Mineral	47.9	25.	47.9	21.7
Homestake Mining	31.2	29.	31.2	28.9
Freeport Minerals	+	20.	+	39.2
Kennecott Copper	+	26.1	45.3	+
Phelps Dodge	43.2	37.3	43.6	35.5
Pittston	42.2	21.5	42.2	14.0
St. Joe Minerals	+	34.3	+	30.6
Westmoreland Coal	31.3	0.	31.3	0.
Average	34.7	25.5	37.9	22.8

Reconciliation

Firm	Percent Depletion	Investment Tax Credit	Foreign Income
AMAX	14	2.9	4.3
Am. Smelt. & Ref.	7.1	2.7	7.1
Anaconda	13	5	4.
Diamond Crystal Salt	+	+	+
Foote Mineral	26.1	11.9	-
Homestake Mining	15	5	-
Freeport Minerals	9	-	17.
Kennecott Copper	17.8 & 4.6 *	2.2	-
Phelps Dodge	9.0	1.9	-
Pittston	15.6	5.3	-
St. Joe Minerals	10.	3.	-
Westmoreland Coal	42.0	-	-

+ denotes unavailable

- denotes negligible

* The two depletion figures for Kennecott refer to minerals and coal respectively; total depletion benefit is 22.4.

Source: Derived from Corporation 10-K Reports.

Table 3-5. TAXATION OF METAL MINING AND FABRICATION INDUSTRY

Tax Burden

Firm	Domestic Efficiency	Effective Rate Reported to SEC	World Efficiency	Federal Income Tax Rate
Alcoa	32.6	34.6	46.8	+
Bethlehem Steel	47.2	42.0	48.7	37.0
Republic Steel	52.4	41.7	52.5	40.6
Reynolds Metals	39.1	29.5	46.6	14.9
Average	42.8	37.0	48.7	30.8

Reconciliation

Firm	Percent Depletion	Investment Tax Credit	Foreign Income	DISC & WHTC
Alcoa	3.3	6.7	-	3.4
Bethlehem	3.4	2.8	.5	1.
Republic Steel	3.5	3.2	-	-
Reynolds Metals *	4.	4.	-	4.

+ denotes unavailable
- denotes negligible
Source: Derived from Corporation 10-K Reports.
* Reynolds Metals obtained a reduction of 4 percentage points from capital gains.

Table 3-6. TAXATION OF MANUFACTURING

	Tax Burden			
Firm	Domestic Efficiency	Effective Rate Reported to SEC	World Efficiency	Federal Income Tax Rate
Am. Air Filter	+	48.0	+	34.4
Am. Hoist & Der.	+	35.7	39.5	25.6
Am. Home Prod.	44.4	49.7	50.9	40.1
Copperweld	51.7	47.6	51.7	44.5
Corning Glass W.	+	50.8	55.2	+
Duro-Test	50.7	47.5	50.7	+
DuPont	45.6	46.3	50.0	41.3
Dow Jones	52.6	51.2	52.6	47.4
Gerber Prod.	+	47.5	52.1	+
General Mills	51.8	39.6	51.8	36.6
Goodyear T. & R.	50.1	45.3	55.4	34.8
Proctor & Gamble	45.8	44.9	51.6	36.9
Safeway Stores	54.9	45.2	59.5	33.6
Westinghouse Elec.	54.7	43.5	54.7	33.2
Xerox	36.7	45.7	50.9	24.2
Average	49.0	45.9	51.9	38.6

+ Denotes unavailable
Source: Derived from Corporation 10-K Reports

tax benefit; it is obtained on an average of 48 percent of the income for the firms in the sample, and reduces their effective tax rate by 8.6 percentage points. (It should be noted that foreign income and foreign income taxes can introduce errors into the estimate of the percent of income taxed at capital gains rates.) For the pulp and paper industry capital gains is also its most important tax benefit; it is obtained on 36 percent of the income for the firms sampled, and reduces their effective tax rate an average of 6.5 percentage points.

For the mining industry percent depletion is by far the most important tax benefit. For this sample of firms it served to reduce the effective tax rate by anywhere from 9 to 42 percentage points. The investment tax credit and the foreign income tax credit against domestic income tax liability are also significant factors reducing effective tax rates.

When rates of taxation of corporate income are measured by dividing the sum of all taxes (e.g. property taxes plus franchise taxes plus severance taxes plus income taxes) by income before any of these taxes were paid, the same variation across industries is observed. The forest products industry averaged 46.9 percent by this measure, pulp and paper 47.2 percent, mining 37.9 percent, mining and fabricating 48.6 percent, and manufacturing 51.9 percent.

In Tables 3-2 through 3-6 several figures are recorded as unavailable. This reflects the common practice of reporting aggregate figures for certain types of taxes. For example, state and foreign income taxes are reported in aggregate, but not separately by Louisiana Pacific and Duro-Test. Others (Gerber and Kennecott) failed to distinguish between foreign and Federal income taxes. Finally property taxes are often included with other non-income taxes, making the computation of the property tax rate impossible for those firms included in Tables 3-2 through 3-6 but excluded from Table 3-1.

CHAPTER 3

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CHAPTER 4

THE REGULATION OF MINERAL DISCOVERY AND PRODUCTION ON FEDERAL LANDS

This chapter diverges somewhat from the major theme of this report to consider economic aspects of present and proposed systems for regulating the discovery and production of minerals on federally owned lands. The proposed revisions of existing law are especially interesting to us in that most would impose new taxes on the mining industry that conceivably could eliminate much of the present subsidization obtained from percent depletion and expensing of exploration and development costs.

The discovery of hardrock minerals is regulated by the General Mining Law of 1872[1] which allows prospectors open access on unclaimed, open public domain lands in the Western United States. Our criteria for evaluating alternative procedures for the discovery of minerals include equity, efficiency, and administrative feasibility. Equity considerations, involving the distribution of income and wealth among present as well as future generations, center on issues such as the timing of discovery and development, and the allocation of economic rents between private and public ownership. Economic efficiency, satisfied when a given output is achieved at least cost to society, is violated when the search for minerals involves unnecessary and unproductive expenditures, as well as when the costs of environmental disruption resulting from mineral exploration and production are not incorporated in mining firms' decision-making. Administrative feasibility refers to monetary and non-monetary costs incurred by the administrators as well as those subject to the regulations.

Present policy fails in several respects to satisfy the criteria for evaluation. There is no centralized management over the timing of exploratory effort. The discovery process rewards exploration by giving away valuable mineral assets rather than offering exploration rights for sale by competitive bid. Although appropriate incentives exist for individuals to produce so as to maximize the present value of economic rents, few if any of these rents accrue directly to the federal treasury. Additionally, the taxation system that does exist serves in part to distort private incentives away from maximization of the rent accruing to all of society. Because of open access there is excessive exploration and the last prospectors to join the hunt for minerals do not contribute as much to the rest of society as they could in alternative forms of employment. A second form of inefficiency is created by the legal system under which claims are filed, and a third inefficiency from the failure to internalize the costs of environmental disruption. Although accumulated experience has demonstrated the feasibility of the General Mining Law, costs incurred by the Department of the Interior in challenging the validity of mining claims and related costs incurred by the mining industry to defend challenged claims have been substantial, judging by the volume of litigation recorded over the past 100 years. In addition to the costs, the fact that the Department of the Interior has records neither of who has claim on which parcels of land nor of the extent of mining following the issuance of mineral patents indicates that the Mining Law leaves much to be desired administratively.

I. THE DISCOVERY PROCESS

The image of the sourdough prospector coaxing his burro through the untamed West is a bit exaggerated today. Today's prospector may drive a Jeep, have access to modern seismic data and other geophysical information, and possess other new prospecting tools. He may be self-employed, but more often works for the mineral exploration arm of a major mining company. The lure of a big strike next time has attracted individuals into this employment out of all proportion to the wages to be earned. Despite the attractiveness of risky propositions to certain individuals, incentives for lone prospectors are rapidly diminishing. Recent developments in capital intensive forms of exploration, such as diamond drilling, airborne magnetic surveys and chemical assays of aquifers by the larger mining companies, have largely supplanted individual effort as a source of new discoveries.[2]

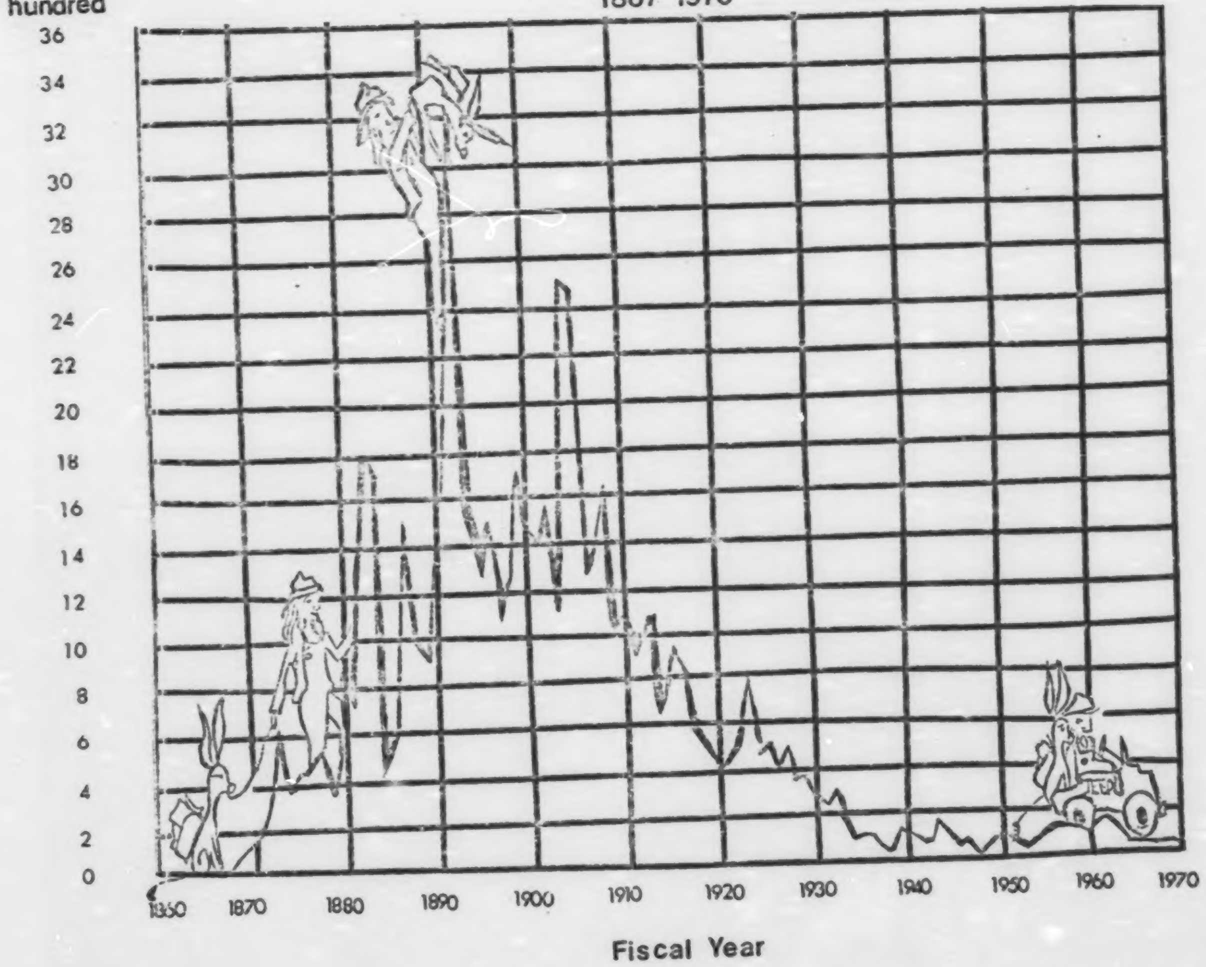
Mining rights on most of the open public domain lands, as distinguished from "acquired lands" which have been obtained through purchase or acquisition from private individuals, are obtained through discovery and development. Exploration proceeds without restraint until a showing of "valuable" minerals is obtained. At that point a prospector can stake a claim for mineral rights under the Mining Law of 1872.[3] The requirement of a "valuable" showing is relevant to maintaining a claim only when the validity of the claim is challenged, and the vast majority of claims eventually prove to be worthless from the standpoint of mineral production. Claims can be of four types: lode claims which follow along a vein of mineralization, placer claims on a 20-acre rectangular parcel, tunnel sites, and mill sites on 5 acres of non-mineral land. To date in excess of 6 million claims are thought to have been filed, many of which have been abandoned. To maintain a valid claim at least $100 worth of effort must be sustained in each year. Under the Mining Law a claim may be voided by a subsequent prospector or the Department of the Interior if $100 of effort each year cannot be proven by the claimant. The effort requirement has been criticized because it is all too often satisfied by the claimant making purposeless scars on the land. In cases where overlapping claims have been filed or boundary designations are subject to dispute, litigation in state courts often ensues.

Surface rights to a mining claim may be obtained through patenting a claim, a long and expensive process, especially in recent years. The requirements include payment of a fee of $2.50 per acre for placer claims or $5.00 per acre for lode claims, and evidence of the possibility of profitable recovery of minerals. Approximately 64,000 patents covering some 2.9 million acres have been granted since 1872[4] (see Figure I). Though patenting confers several definite advantages to the owner of a mining claim including fee ownership of the land, the elimination of possible challenges from other claimants or governmental agencies, and increased ease of financing through outside sources, patenting also has a distinct disadvantage. The patenting process involves both procedural and substantive requirements, and a claim is invalidated if it is determined that the requirements have not been satisfied. A patent applicant thus faces the real risk of losing his claim should the patent be denied.

In the 1920 Mineral Leasing Act[5] certain minerals, primarily coal, oil and gas, were excluded from disposition under the Mining Law. By 1973 some 68 million acres of Federal lands were under lease for oil and gas and about 800,000 acres were under lease for coal.[6] The Material Disposal Law of 1947[7] and its extension, the Multiple Surface Use Act of 1955[8], excluded several common materials such as sand, gravel, pumice, and clay from location under the Mining Law and provided for their sale at fair market value.

The main difference among the three mechanisms for mineral development is that the Mining Law of 1872 acts as a self-executing law and does not allow the Secretary of the Interior to weigh alternative public values as he may do under the other systems of development before approving applications for title. Under the Mining Law of 1872 the Secretary has utilized two basic approaches to deny the statutory grant of rights in situations where he feels mineral development is inconsistent with proper land use policy. First,

FIGURE 4-1
MINERAL PATENTS ISSUED
1867-1970



he may withdraw lands from the domain of public land laws, rendering the Mining Law inoperable. The second approach has been to apply increasingly restrictive tests for the determination of value.

In the absence of Congressional reform of the Mining Law for the disposition of hardrock minerals, the Department of the Interior, through decisions rendered by the Secretary of the Interior until 1952, the Solicitor of the Department of the Interior from 1952 to 1970, and the Board of Land Appeals since 1970, effected indirect reform through increasingly strict interpretations of the Law. The terms "valuable" and "discovery" in the 1872 Law were defined in the case Castle v. Womble[9] in what has subsequently become known as the "prudent man rule".[10] This rule indicates that there is value when a "man of ordinary prudence would be justified in the further expenditure of his labor and means, with a reasonable prospect of success, in developing a valuable mine..."[11] Although the language of Castle v. Womble makes no explicit mention of profitability, the Department of the Interior, in a long series of subsequent decisions, held that the prudent man would take into account prospective profitability before investing his labor and means.[12] The marketability test of value, as it came to be known, reached its final explication in United States v. Coleman[13] with the Secretary's decision that present marketability at a profit was required for discovery. Though the marketability test of value may be deemed desirable by the Secretary for unstated social purposes, it diverges significantly from the conventional economic test in which value is associated with positive market prices. For example, the title to low-grade copper deposits may be of substantial value to those willing to speculate on rising prices in the future or on the development of new techniques of extraction, yet the copper deposit may be highly unprofitable should it be mined today.

The use of mining claims for purposes other than mining has been extensive. Under the Mining Law of 1872 the owner of a mining claim has the right to disturb the surface in search for minerals, including such acts as cutting timber and erecting structures necessary for mining operations. In some cases summer homes have been built on otherwise worthless mining claims.[14] The owners face the risk that the Federal Government may challenge their claim on the grounds that valuable minerals have not been found. If the challenge is sustained the property reverts to government ownership. Others have filed mining claims on land in the path of urban growth (as in the thousands of claims for sand and gravel near Las Vegas) hoping to profit from use of the land as a commercial site.

Mining claims, though filed for a specific mineral, convey the right to remove other minerals. As relative mineral values change, old claims may be challenged in state courts by those who would like to obtain mining rights for other minerals. The challenge may be on the grounds that the boundaries of the original claim were incorrectly specified, that less than the requisite $100 effort has been done yearly, that the "valuable" discovery has not been made, and a host of other points.

The discovery procedure frequently acts perversely when it serves to retard the production of minerals. The area surrounding the site of a major discovery usually becomes dotted with other speculative claims which may hinder further development. Not only is it expensive to negotiate with so many different claimants, but each one has an incentive to hold out for a disproportionate share of anticipated future profits. Dormant mining claims serve as a deterrent to new exploration because of the significant costs of having them declared invalid.

Development of a mining property involves capital requirements on a scale which normally requires access to financial markets. Because of risk reduction through diversification of activities, the larger mining companies are able to obtain financing on more favorable terms than would the lone prospector. Capital requirements force the owners of many undeveloped mining claims to solicit offers from the major mining companies if the properties are ever to reach the producing stage. The larger mining companies have obtained much of their producing property in this fashion.

Prospecting on closed (private) land differs from that on public open access land in that some bonus, lease, or royalty is normally arranged before prospecting begins. The landlord captures some of the rent and prospecting is less motivated. Another factor which tends to limit exploration on private lands is that the rational landowner would want to postpone exploration effort in the hope that exploration on adjoining properties would reveal information as to the mineral content of his property.

A third land tenure arrangement has evolved on former public domain lands where surface rights have been disposed of through statute. The separation of surface and mineral rights on these lands has led to a number of unfortunate situations where mineral exploration and even mining occurs in residential areas.

Factors other than the General Mining Law which affect industry decisions on the timing of and investment in exploration include the nature of competition in the industry and Federal and state tax policy toward the mineral industry. The industry setting of imperfect competition serves to stimulate preclusive preemption to the industry base to strengthen competitive positions. Firms place a high value on the discovery of resources because they may later be rewarded by monopoly rents. Vertically integrated firms often attempt to gain control of raw material supplies. Mancke observed this tendency in the steel industry in the late nineteenth century, the apparent motivation of the steel producers being to prevent the formation of an iron ore cartel that might threaten the profitability enjoyed by the steel industry.[15]

Federal tax policy appears to operate to stimulate exploration, though a comprehensive review of the effects is beyond the scope of this paper. On balance the expensing of exploration and development expenditures serves as an interest-free loan from the treasury in the amount of the deductions, when one compares this policy with the alternative of treating such outlays as investments. Though Miller has argued that percent depletion discourages exploration, it would appear that by making mineral discoveries more valuable, percent depletion would serve to stimulate exploration effort.[16]

The effect of the property tax on exploration deserves special consideration. Mining claims are not subject to a property tax until they are patented. Minerals can be removed from unpatented claims, making the impact of property taxes on exploratory efforts on open public lands minimal. On private lands property taxes may be revised upward following mineral discovery. This factor may serve to reduce the incentive to explore. The administration of property taxes is an extraordinarily complex subject involving thousands of rates, districts, and administrative decisions. Any impact of property taxes on exploration efforts could be minimized by reducing taxes on properties where mineral production is uneconomic, while raising it in successful properties.

II. ECONOMIC CONSIDERATIONS FOR OPTIMIZATION IN EXPLORATION

There are two basic tests of the social desirability of the discovery process. First, is exploration effort timed in a manner that is consistent with national policy objectives? Second, are inputs to the discovery process used efficiently? Because there is little, if any, governmental regulation or other form of influence on the timing of exploration, there may be a divergence between decisions made by the mining industry and national policy objectives. The legal setting of open access favors the inefficient use of exploration inputs; in addition, the decentralized and often lax recording of claims needlessly increases discovery costs.

That exploration should precede production by many years is suggested by information requirements regarding the quality and extent of domestic ore supplies which should be an input to the development of a national materials policy. Additionally, if the commencement of production is to be optimally timed, the values of all mineral leases and claims should be accurately known. This is difficult in the face of the tremendous uncertainty which precedes thorough exploration. Certainly the reticence of the mining industry to reveal the true extent of probable reserves compounds the difficulty of making Federal mineral policies. A factor which argues against complete knowledge of reserves is that idle reserves in and of themselves are not productive. If social welfare is to be measured strictly by output, society would be better off to defer exploration outlays until just before production is scheduled to begin, and channel investment funds into productive areas in the interim. Moreover, as technological improvement in exploration continues, the real costs of discovery should decline, further arguing for a slowing of the pace of exploration. As long as the timing of exploration is controlled by mining firms rather than subject to some form of central control, there is a strong chance timing will be premature from the viewpoint of society as a whole. Rather than being motivated by national policy objectives the individual firms are stimulated to explore by profit-maximizing considerations. Individual profit-maximizing behavior fails to maximize societal welfare both when the rate at which future profits are discounted by individuals differs from the social rate of discount, and when individuals are induced to explore in order to strengthen market positions.

The second question to consider is efficiency in exploration. In theory, and ignoring considerations of risk, inputs to any production process should continue to be hired so long as the value of their marginal product continues to exceed their cost. For mineral exploration there is no central authority with the responsibility for the determination of the marginal productivity of additional prospecting effort. Individuals are guided in their decision to prospect by the expected (average) wage in the industry (or may be willing to accept even less if they are attracted by the remote prospect of a big strike). Assuming diminishing returns to prospecting, as a result of a decline in the quality of lands being searched, the average wage will exceed the incremental value of the contribution to total discovery value made by the last few prospectors. These marginal prospectors, though themselves earning the average wage, depress the incomes of the earlier entrants to the field, so that in terms of their net contribution to discoveries their effort is unjustified. Again individual profit-maximizing decisions lead to a lower level of social welfare than would occur under centralized management of exploration.

Although we have in principle answered the question of the optimal amount of prospecting effort, there exist a number of possible externalities which could alter the conditions for optimality.

They include:

(1) An information externality in that one discovery may make it easier to find minerals in the same or similar geological formations.

(2) An exploration externality resulting from duplication of effort - searching the same land more than once.

(3) The "Easter Egg" externality in that each discovery increases the cost to all other prospectors in making their next discovery.[17] (There are a fixed number of mineral deposits and finding one makes it just that much more difficult to find the next one.)

In commenting on these externalities we note that a beneficial externality, such as the first, would require the optimal exploration effort to be greater than indicated by the marginal productivity criterion, whereas a negative externality, such as the second, would indicate the criterion calls for excessive exploration. The third externality deserves special consideration. It is true that each successive discovery raises the cost of subsequent discoveries, especially in the absence of externalities of the first type. If one views exploration as a sequential searching process, identical prospecting efforts in successive years will be expected to yield progressively lower returns. This is merely the famous "pecuniary" externality where firms face a rising supply curve for an input (mineral reserves) and appropriation of the input by one firm raises the cost to subsequent users. As such it does not result in a misallocation of resources and calls for no deviation from the optimality criterion.

III ECONOMIC CONSIDERATIONS FOR OPTIMIZATION IN PRODUCTION

In theory (and probably in practice) the production of minerals by corporations is governed by the maximization of the present value of profits from a mine. Thus production decisions are affected by profitability variables such as taxation, ore grade, mineral prices, and extraction technology, all of which are factors unrelated to the operation of the General Mining Law. The primary, if not the only, function of the General Mining Law is control over the process by which the ownership of minerals in place is transferred from public to private hands. As we argue below, the neutrality of the Mining Law with respect to production decisions permits the attainment of the same social welfare optimum that would result from the unrestricted activities of individual mining companies. Most recent proposals to revise the Mining Law would affect production decisions, either through taxation, royalties on leaseholds, or requirements that production commence within a stated period to maintain rights to a leasehold. This section examines the impact of taxation and other regulatory mechanisms on the production decisions of mining firms as a prelude to the critical evaluation of the proposals to revise the Mining Law.

The maximization of the present value of producer's plus consumer's surplus will be used as the criterion of optimality in production. This choice may appear a bit artificial, but it has been used previously in intertemporal models and as Peterson shows is equivalent to efficiency in the more conventional terms of price and marginal cost.[18] Hotelling first demonstrated the efficiency of a competitive mining industry.[19] He showed that a competitive industry which maximizes the present value of profits chooses exactly the same production path as a centrally planned economy which maximizes the present value of producer's plus consumer's surplus. A monopolistically controlled industry would fail to achieve optimality by maintaining a difference between price and marginal cost. Compared with the centrally planned economy's production path the monopolist restricts output.

In the competitive model firms maximize the present value of profits, which is just the present value of producer's surplus (the difference between price and long-run marginal cost), and may properly be termed economic rent when marginal cost measures the opportunity cost of each input. Economists have long argued that taxation of rent is socially desirable, such taxes being non-distorting. Additionally one might argue that mineral production on public lands should not earn long-run profits above the minimum necessary to attract the investment that does take place. Equity with respect to the allocation of public resources would indicate that some (the mining companies) should not benefit at the expense of the many.

We are led then to an examination of the effect of various forms of taxation on the allocation of rents and on the optimal timing of production. Hotelling and Peterson both analyzed the impact of taxation on production. Their results are summarized below. A pure profits tax is a tax on economic rents; it does not distort the timing of production from that which is socially optimal. The income tax distorts production decisions because of the manner in which investment is treated. Rather than being written off as incurred, investment for exploration and development of productive ventures must be capitalized and depreciated over time. The depletion allowance as it is written in the tax code serves to accelerate the timing of production over what it would be with ordinary income taxation. In recent sessions of Congress hearings have been held on legislation that would impose a Federal severance tax or royalty payment on output. A severance tax would have the consequence of postponing

Tax	Effect on Timing of Production
pure profits	neutral
income	delayed
severance	delayed
property	advance or neutral

output and would also serve to transfer some of the economic rent to the Federal government.

Taxes such as royalties and severance taxes serve to lessen the differential in value between the use of land for mineral production and some alternative purpose, even if the alternative use is merely to serve the needs of an occasional hiker or hunter. As long as the land continues to be used for mineral production the government obtains a share of the rent that previously accrued to the owner of the land. By applying royalties or severances on the gross value of output, the extensive margin of land use for mineral production will be curtailed.[20] A tax on net receipts (accounting profits) would be better in that more profitable operations would pay larger taxes per ton of ore removed, but better still would be a tax on pure economic profit (rent). In theory this would be administered by taxing only that portion of profits from each operation above that which reflects a normal rate of return on the investment (properly adjusted for risk).

IV. REVISING THE MINING LAW OF 1872

Significant modification of the General Mining Law occurred with the enactment of the Mineral Leasing Acts of 1920 and 1947[21] and the Material Disposal Law of 1947.[22] The former served to exclude most energy minerals from location through the Mining Law, and the latter provided for the sale of common materials such as sand, gravel, and clay obtained on public lands at fair market value. The wisdom of having three separate systems for the development of minerals on Federal lands is questionable, especially considering that the minerals subject to disposal under different systems may be intermingled in the same deposit. The Multiple Mineral Development Act[23] was an explicit attempt to deal with this problem of administration. The passage of the National Wilderness Areas Preservation Act[24] and the establishment of the Public Land Law Review Commission[25] presaged a revival of interest in an examination of the desirability of the Mining Law as an instrument of national policy.

Most of the land that was placed in wilderness status by the National Wilderness Areas Preservation Act had been open to mining and in many areas claims had been filed and even patented. Rather than halt all current mining efforts or deny rights that had already been conferred through patenting, Congress opted to allow prospecting and mining until January 1, 1984, presumably a sufficient time to allow fixed investments to be recovered. The Act specifies that it is Federal policy "to secure for the American people of present and future generations the benefits of an enduring resource of wilderness."

In the act establishing the Public Land Law Review Commission

> "it is hereby declared to be the policy of Congress that the public lands of the United States shall be (a) retained and managed, or (b) disposed of, all in a manner to provide the maximum benefit for the general public."

By this declaration Congress reinforced the trend away from what some have viewed as indiscriminant disposal of Federal lands under such laws as the Homestead Law[26] and the General Mining Law. As land became more scarce, disposal as an instrument of public policy gave way to leasing and sale through competitive bidding. The open access to minerals on public lands is one of the few remaining vestiges of our former national policy.

The Mineral Leasing Act of 1920 excluded most energy minerals from location and provided for the awarding of lease privileges through competitive bidding. By leasing, rather than allowing open access, the dissipation of economic rent through excessive and premature exploration can be eliminated. Presumably the Interior Department can weigh the social benefits from alternative uses of Federal lands before it decides to offer them for lease. Also the regulation of mining activity is simplified if tracts are large and records of ownership are kept in a single location. The welfare of future generations may or may not be factored into governmental decisions but at least there is reason to believe it will be given more weight than in private decisions to explore when open access is allowed. Uncertainties associated with possible withdrawal of exploration rights still exist as a deterrent to prospecting effort and may serve to adversely affect bidding for oil and gas leases.

The principal defect of the Mineral Leasing Act of 1920, from the viewpoint of economic efficiency, is the manner in which production leases are awarded for lands not known to be mineralized. The Act specifies that parties interested in obtaining a noncompetitive oil or gas lease must file simultaneously, the winner to be chosen in a random drawing. Typically, parties awarded the leases are not in the petroleum industry and sell the lease to one of the major petroleum companies in a contract that provides for a royalty to the seller. No part of this royalty accrues to the Federal government (other than through income taxation). This system encourages excessive investment in the socially nonproductive act of filing for the leases. Social welfare would be increased if this nonproductive effort was discouraged and a system of competitive bidding established (as is done for lands known to be mineralized).

The leasing process for coal and phosphates requires that they often be granted without competition, a system that may, depending upon leasing fees, transfer economic rent from the Federal government to private investors.

At least four bills were introduced recently in Congress that would modify the operation of the Mining Law of 1872 as it pertains to hardrock minerals. These are S 1040, the proposed "Mineral Leasing Act of 1973;" S 3085, the proposed "Hardrock Mineral Development Act of 1974;" S 3086, the proposed "Mineral Development Act of 1974;"

and HR 8435, the proposed "Mineral Leasing Act of 1975." The following paragraphs outline the provisions of each of these bills and analyze their efficacy in producing socially desirable changes in the Mining Law.

S 1040, which was supported by the Administration and the Interior Department and strongly opposed by the organized mining interests, would have repealed the Mining Law of 1872, the Mineral Leasing Act of 1920, and related laws, and in their place would have:

(1) Instituted a system of leasing for the exploration of all minerals. The leases would have been issued by competitive bid only when there was evidence of minerals in paying quantities; otherwise leases would have been issued without charge, and would have been valid for a period of ten years.

(2) Instituted a second type of lease for production, valid for from five to twenty years and automatically renewable if minerals were being produced.

(3) Established minimum annual rental fees per acre on all leases.

(4) Established a minimum royalty on production.

(5) Required submission of plans for operation and reclamation prior to commencement of mining, and compliance with these plans throughout.

(6) Given the Secretary of the Interior the authority to remove lands from the operation of the Act to protect the environment or to promote alternative uses of the land, and also given the Secretary the right to waive or reduce fees and royalties on certain properties to encourage development.

(7) Limited hardrock mineral leaseholdings under control of one corporation to 20,480 acres in one state and 640 acres in one lease.

(8) Required that all existing claims be recorded within one year of enactment of the Act and a patent applied for within three years.

If properly implemented by the Secretary of the Interior, this bill would have corrected the major objections to the Mining Law of 1872 previously raised. Timing of exploration would have been under centralized management, and with restrictions on entry there would have been far less of an incentive to excessive exploration effort. With entry restrictions on a lease, decentralized prospecting decisions are (theoretically, at least) guided by a prospector's marginal product, a force that should lead to efficient use of prospecting inputs. Uncertainties over ownership would have been resolved. Larger leases should eliminate the externalities associated with excessive adjacent claim filing near productive discoveries. Control over use and the evaluation of alternative land uses would have rested with the Secretary, who presumably would make decisions consistent with the maximization of social welfare.

Contrary to the remarks of Howard Edwards of the Anaconda Company that offering leases through competitive bidding, as proposed by this bill, "...is not a fair way to allocate leases because the practice discriminates against small miners, is an economic waste, discourages development and investment..."[27], the taxation of true economic rent (as in a bid for a lease) is desirable because it serves to allocate investment according to the marginal productivity criterion. It is true that bidding for leases can involve substantial sums and this factor would definitely serve to deter the small prospector. In the past the small prospector has been instrumental in the discovery process; Koehler Stout, President of the Montana Mining Congress, terms them the "bird dogs" of the industry.[33] If their efforts truly are more productive than similar outlays by large mining companies, the interests of both prospectors and mining companies would be served by formalizing their relationship in an employment contract (containing suitable incentives for discovery).

The "Hardrock Mineral Development Act of 1974," S 3085, is similar to S 1040 with the following exceptions:

(1) It would have applied only to hardrock minerals.
(2) It did not specify guidelines for competitive bidding on leases.
(3) It did not specify that the Secretary would have discretion over the issuance of exploration leases.
(4) Production leases could have been held for 40 years without any production as compared to 20 years under S 1040.

The differences between S 3085 and S 1040 were primarily in the scope of coverage and the authority vested in the Secretary. The economic implications are clear. Inefficiencies in other than hardrock mineral exploration and production would not necessarily be subject to evaluation by a centralized decision-making unit. Also the absence of competitive bidding for leases would result in a loss of economic rent to society and its appropriation by the winner of the lease.

The proposed "Mineral Development Act of 1974," S 3086, was preferred by the American Mining Congress, an association of large mining companies, and was opposed by (1) various smaller associations representing lesser mining companies for whom capital requirements would have been burdensome, and (2) the Department of the Interior. Among other things this Act would have:

(1) Provided for the elimination of existing unpatented claims unless a new claim was filed within five years of the date of enactment of the Act.

(2) Had new claims recorded both in the county recording office and in the regional office of the Bureau of Land Management, and filed for 80 acres in a manner that conforms with legal subdivisions of public land.

(3) Eliminated the present distinction between lode and placer claims.

(4) Increased the annual labor requirements substantially.

(5) Continued the present system of patenting, though only at a substantially higher fee. Patents would have only conferred the right to extract minerals and would not have allowed full freedom to utilize the site for other purposes as is the case under present law.

(6) Instituted a system of royalties of 2% of the value of minerals mined subject to the restriction the royalty be less that 5% of net income.

This bill would have resolved many of the ambiguities over ownership by eliminating all old claims for which there was no current active interest. By collecting all claim information in a central repository (BLM), potential claimants should enjoy significantly lower search costs in determining whether or not a given parcel has been claimed. Presumably the provisions restricting use of patented sites to only those directly connected with the production of minerals would have eliminated the abuses that have occurred on these sites.

The provisions for environmental protection in these bills differed substantially in degree. S 1040 would have had the most stringent requirements, the operation and reclamation plans which would have had to have been approved before development and followed thereafter. S 3085 would have been less restrictive by not requiring such comprehensive planning, nor would it specifically have vested authority in the Secretary to reject the issuance of exploration leases or bids for leases when he felt it was in the public interest to do so, as he could under S 1040. S 3086 would have given the Secretary even less authority to deal with problems of multiple use and environmental damage.

HR 8435, the proposed "Mineral Leasing Act of 1975," was drafted largely by Lawrence MacDonald, a Colorado School of Mines professor of economics. This bill would revise the entire system for mineral disposal including hardrock minerals, oil and gas, construction materials, and bedded minerals such as oil shale and sulfur. The existing systems would be replaced by a three-stage leasing system in which the Federal government would retain ownership and control over the land. Strong environmental safeguards would accompany each stage. Inasmuch as the principal concern of this paper is hardrock mineral development under the General Mining Law, the discussion of HR 8435 will deal primarily with the regulation of hardrock mineral development.

In stage one the Secretary of the Interior would, at his discretion, issue a prospecting permit allowing only surface reconnaissance to any person making a valid application. Each permit would be valid for a period of two years and would be subject to a nominal fee to cover administrative costs.

In stage two exploration leases would be issued which would give exclusive exploration rights to the leaseholder. Where two or more persons file exploration applications on substantially overlapping territory, the Secretary would offer the lease competitively to the highest bidder. A rental fee of at least 50¢ per acre per year would be charged; the size of each lease would be limited to a maximum of 640 acres; and the extraction of minerals would be limited to quantities required for chemical analysis.

In the third stage a development and production lease would be issued by the Secretary to persons showing that deposits exist in paying quantities. Lease applications would be able to be revised to include other minerals should they be discovered during subsequent development. Leases would be issued for a twenty-year term and continue thereafter as long as production continued. A fee of at least $1 per acre per year would be imposed and the fee would be increased each year following the sixth if production had not commenced. Before extraction operations could begin a comprehensive plan for operations and reclamation would have to be approved by the Secretary.

Holders of existing mining claims would be forced to record them within one year of the date of the Act, and to file an application for a patent or a development lease within three years of recordation of the claim.

HR 8435 would eliminate most of the undesirable features of discovery under the General Mining Law. Furthermore, the imposition of strong environmental controls in an area so conspicuously lacking in controls must be viewed favorably. Despite these desirable features, distortions in the intertemporal allocation of resources could result from the pressure that would be placed on prospectors to bring mines on stream at an early date.

A rational mining firm maximizing the present value of its profits would begin development of a deposit when the return earned on holding the undeveloped deposit just equalled the return available on alternative investments - that is, when the rate of increase in value of a deposit equals the market rate of interest. As Hotelling showed, the profit-maximizing activities of a competitive mining industry would maximize societal welfare. When a regulatory system is instituted which imposes penalties for delaying development, the mining firms having development and production leases on marginally valuable deposits are forced to accelerate the timing of production if they want to avoid losing their rights under the lease. Such penalty provisions may indeed stimulate mining activity in the near future, but only at the cost of denying these minerals to future generations. The production incentives are undesirable because they would distort what are, in principle, decisions consistent with the maximization of social welfare.

CHAPTER 4

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CHAPTER 5

TAXATION AND TIMBER RESOURCE ALLOCATION

This chapter is divided into four sections. The first considers the nature of preferential taxation of forest property. The second section analyzes the impact of various forms of taxation on forest management decisions. The third section reviews the available evidence on industrial structure as it affects industry supply curves. The final section briefly treats some of the non-tax federal policies and regulations which affect the forest product industry supply curve.

I. FOREST PROPERTY TAXATION

As shown in Chapter 3, the income and property of the forest product industry is taxed preferentially, compared to general manufacturing. The principal tax subsidies to the forest product industry are capital gains treatment of profits from stumpage held for the requisite periods and reduced rates of property taxation.

Capital gains treatment of income derived from increases in the value of standing timber has been cited by Sunley, among others, as a form of preferential taxation of the forest product industry. As recapitulated in the historical review of Chapter 2, prior to 1944 the timber owners could obtain capital gains only when long term holdings of timber were sold while still standing. The extension of capital gains treatment to long term profits on appreciating corporate assets in 1942 created an inequity between corporations who processed their own timber and those who sold standing timber.[1] In 1944 Congress amended Section 117 of the Internal Revenue Code to rectify this inequity. At the time this amendment was being debated it was suggested that liberalizing the tax treatment of timber profits would stimulate the output of forest products. Prior to 1942 neither group could obtain capital gains treatment; after 1942 only the latter group was entitled to take capital gains on long term stumpage profits.

Ordinary property taxes serve to shorten growing cycles and accelerate the rate of timber harvest. In addition, a system of uniform land and income taxes which did not discriminate by use or activity would lower private returns to forestry relative to other uses of the land and induce a conversion of forest land to other uses. The social benefits of forest land, which include the value of recreational opportunities and the like, may exceed private returns; therefore some form of public subsidization of forestry may be desirable if other uses of the land which yield lower social benefits are to be forestalled.[2,3,4] The subsidization of forestry through modification of the property tax takes a variety of forms, whose distribution among states is reported in Table 5-1.

Property tax treatment varies by locality and includes special treatment such as exemption and rebate laws, modified property tax laws, yield tax laws, and severance tax laws.

Exemption laws serve to remove forest lands and timber or timber alone from the property tax rolls for a term of years, or in certain instances, indefinitely. Most exemption laws require certain management techniques such as the planting of a particular variety of tree, the creation of snow or wind breaks, or the development of recreational opportunities for continued qualification under the law. Rebate laws allow the owner to apply for a reduction in his taxes in return for public benefits from the use of his lands. Exemption and rebate laws both suffer from complexity and unevenness of administration according to the Georgia Forest Research Council report.

Property tax laws for forest property have been revised by various states to lower the tax burden on timber (and agriculture) relative to other possible land uses. Modifications in property taxation procedures have included altering the assessment irrespective of other uses

Table 5-1. CLASSIFICATION OF FOREST TAX LAWS BY STATE AND TYPE OF LAW (as of 1973)

State	Exemption or Rebate	Modified Assessment	Modified Rate	Yield Tax	Severance Tax
Alabama	X	X		X	X
Arkansas		X	X		X
California	X	X			
Colorado	X				
Connecticut		X		X	
Florida		X			
Hawaii	X	X		X	
Idaho	X			X	
Indiana		X			
Iowa	X	X			
Louisiana				X	
Maine		X			
Maryland		X			
Massachusetts				X	
Michigan				X	
Minnesota			X	X	
Mississippi				X	
Missouri				X	
New Hampshire	X	X		X	
New Jersey	X	X			
New Mexico		X			X
New York				X	
North Carolina	X	X			
North Dakota			X		
Ohio			X		
Oregon		X		X	X
Pennsylvania		X			
Puerto Rico	X	X			
Rhode Island	X	X			
Tennessee	X	X			
Virginia					X
Washington		X		X	
West Virginia					X
Wisconsin			X	X	
TOTAL	12	23	5	19	6

Source: Timber Tax Journal, Vol. 10, p. 185.

which may be better in terms of maximizing land value, changing the rate from that applied to other property, and deferring payment until the timber is actually harvested.

The yield tax substitutes a tax at harvest for the annual property tax on timber. The property tax on land is often retained. The primary purpose of the yield tax is to aid forestry by eliminating the annual tax on timber.

Severance taxes, like yield taxes, are imposed when timber is harvested. Unlike yield taxes, severance taxes are imposed in addition to existing property taxes, and are used primarily as a source of additional revenues. Frequently the proceeds of a severance tax are devoted to State forest programs.

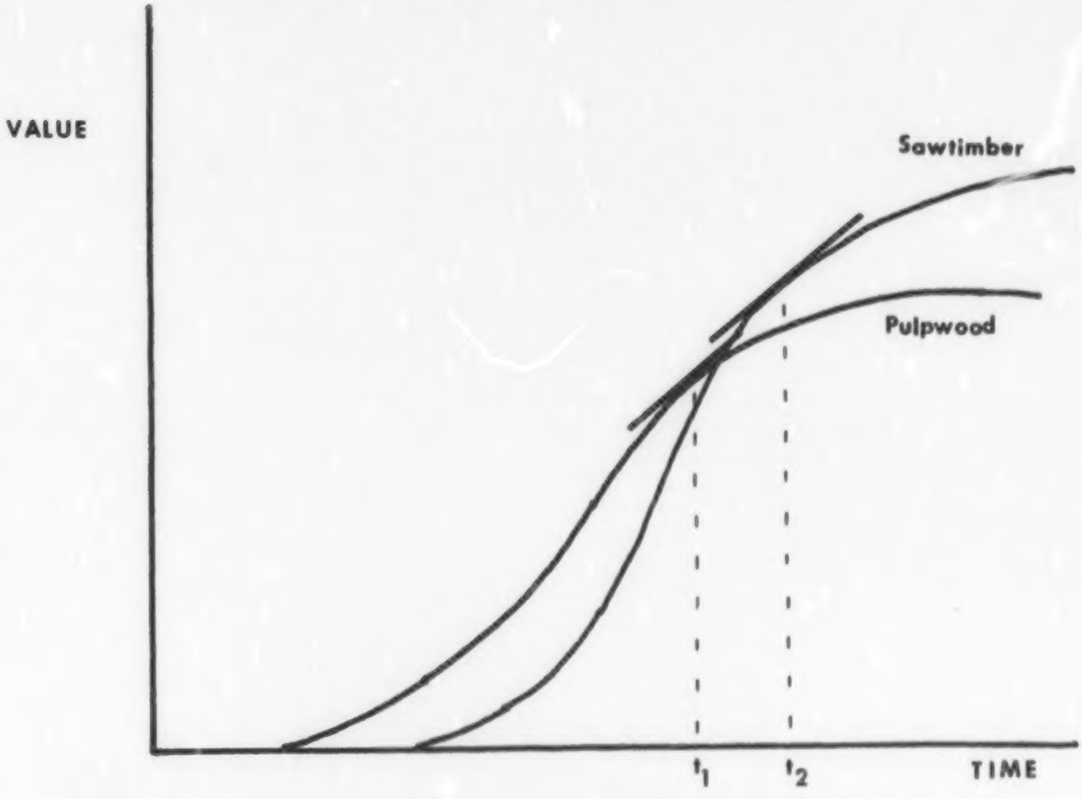
II. EFFECTS OF TAXATION ON FOREST MANAGEMENT DECISIONS

The determination of optimal (profit maximizing) growth periods for appreciating assets such as trees, liquor, and livestock has a long history in the economic literature.[5] Recently this work has been generalized by Thomson and Goldstein to include the effects of taxation.[6] Assuming a single harvest of a forest growing on a given plot of land, with lumber prices constant, one would wait until the gain from postponing the harvest one period equaled the interest foregone. This result may also be expressed as waiting until the rate of increase in value ceases to exceed the interest rate. The condition for profit maximization is depicted graphically in Figure 5-1. Profit maximizing growth periods for an infinite sequence of harvests, and for various forms of taxation of forestry, are considered later in this section.

The calculation of profit maximizing growth periods may result in ambiguity. There are two primary uses for the timber in most forests, pulpwood and sawtimber. These uses are not mutually exclusive in that the same logs that are used for pulp may also be used for sawtimber (and vice-

FIGURE 5-1

YIELD CURVES FOR PULPWOOD AND SAWTIMBER



versa). As Goundry[7] shows, the logistic curve of value for pulp logs normally crosses that for sawtimber. Figure 5-1 depicts this situation. According to the optimizing conditions there are two equally desirable dates of harvest, t_1 for pulpwood and t_2 for sawtimber.

The key to solving this apparent dilemma is to reconsider the criterion for optimization. The rule developed in the previous chapter is to maximize the net present value of the asset. Although calculus may well indicate two dates where both first and second order conditions are satisfied, in general only one can be the global optimum. At low interest rates sawtimber has the highest present value, but as interest rates rise the initial present value superiority of sawtimber gives way to the faster growth and shorter maturity of pulpwood. Thus the interest rate can be a crucial factor, not only in the determination of optimal harvest date, but also in the type of wood grown.

The analysis can easily be generalized to include planting costs and an infinite cycle of harvests. Let:

$V(t)$ = Present value of timber measured from the planting date
t = Number of years in the growth period
$f(t)$ = Harvest value at time t
i = Discount or interest rate
P = Planting costs (incurred at $t=0$)

Present value is maximized when $dV/dt = 0$.

$$\frac{d(f(t)e^{-it} - P)}{dt} = f'(t)e^{-it} - if(t)e^{-it} = 0 \tag{5}$$

Rearranging, one finds $f'(t)/f(t) = i$.

Planting costs have no effect on the optimal date of harvest in this model. The model may be too simplistic, however. It has been suggested that a variety of planting techniques are possible and that growth is affected by the choice of planting technique. This indicates that planting costs are properly included as an argument in the timber value function, in which case planting costs would affect the optimal date of harvest.

For an infinite series of harvests t years apart the present value of the harvest may be written

$$S = f(t)e^{-it} - P + f(t)e^{-2it} - Pe^{-it} + \dots + f(t)e^{-nit} - Pe^{-(n-1)it} + \dots \tag{6}$$

Recognizing that this is merely a geometric series, with initial term $f(t)e^{-it} - P$ and common ratio e^{-it}, the sum may be written as:

$$S = \frac{f(t)e^{-it} - P}{1 - e^{-it}} \tag{7}$$

$$S = \frac{f(t) - Pe^{it}}{e^{it} - 1} \tag{8}$$

Maximizing with respect to t provides the result that trees should be cut when:

$$\frac{f'(t)}{f(t)} = i\,\frac{1 - P/f(t)}{1 - e^{-it}} < i \tag{9}$$

That is, the optimal harvest date is earlier than in the one cycle case, so long as e^{-it} exceeds the ratio of planting costs to harvest value. Now e^{-it} will approach zero for large values of t, while planting costs should be but a small portion of the harvest value, assuring the shortening of harvest cycles.

Forest industry taxation induces adjustments in growing and harvesting cycles by altering the profit maximizing conditions. Thomson and Goldstein (page 32) demonstrate that the effect of the severance tax is to lengthen the optimal growth period, while their specification indicates that income and capital gains taxes are neutral with respect to growth periods. They do not explicitly analyze the effect of the property tax - either in the above form or in its various deferred applications.

The property tax formulation based on value of the timber stand is not readily amenable to analysis. An alternative formulation which assumes taxes are uniform at amount T per year may be readily solved.

$$\frac{f'(t)}{f(t)} = i \left[\frac{1 - P/f(t)}{1 - e^{-it}} \right] + \frac{\frac{t}{if(t)} \left[1 + e^{-it} \right]}{1 - e^{-it}} \qquad (10)$$

Because the second term on the right hand side of this expression is always positive, the rate of increase in value, f'(t)/f(t), is larger than it was in the absence of taxation. A property tax which is constant through time serves to shorten the growing period, resulting in premature harvests.

Unfortunately the Thomson-Goldstein analysis fails to recognize a more subtle impact of taxation on optimal (profit maximizing) harvest dates, and consequently their results may not be valid. Consider, for example, the income tax. The work of Mieszkowski[8] and Harberger[9] demonstrated that under some very general assumptions an income tax is largely a tax on capital, and hence would serve to alter relative factor prices in the production of timber. The Thomson-Goldstein production function contains time as its only argument, but surely a general formulation would include both capital and labor as well. Taxation of capital in forestry at a rate below that in general manufacturing (through capital gains treatment of increases in stumpage value) would serve to lower the cost of capital in forestry relative to other industries. Because capital-labor substitution in forestry is unknown, one can only speculate on the results. It appears that more of the relatively cheap capital (land) will be used and less effort will be devoted to labor intensive activities like thinning and spraying. This effect through capital-labor substitution would tend to slow growth rates, lengthen the profit maximizing growth period, and thus reduce the supply of timber. At the same time, of course, a lower tax rate on timber ownership will affect land use decisions at the margin. The lower is the rate of taxation of timber profits, the more land that will be devoted to timber growing. The net effect between the two countervailing forces (more timber land, but each acre producing less) is ambiguous without a more rigorous treatment of this problem.

Recently, Hartman[10] extended the modeling of optimal harvesting decisions to include non-timber values. Specifically, he considered the case where a standing forest provides flood control, recreational, or other services. The conditions for optimality, which are derived analogously to the equations 5 through 9, indicate that the forest should be harvested when the flow of non-timber benefits plus the growth in forest value ceases to exceed the interest foregone. If non-timber benefits are large relative to the value of the standing timber, this indicates that the harvest should be postponed, perhaps indefinitely. Hartman did not analyze the structure of taxes which would be necessary to internalize this externality.

III. INDUSTRIAL STRUCTURE

The forest product industry may be divided into two broad categories: smaller timber owners and diversified corporations active in all phases of the industry. Among diversified forest product corporations Fortune has long distinguished between paper companies and integrated forest product companies, but such a distinction may be unwarranted. Nearly all of the paper companies are significant factors in the production of lumber, plywood, and chemicals, while most of the firms classified as diversified forest product concerns produce large volumes of pulp and paper from wood residues. In addition, there are a number of smaller firms that specialize in a narrower segment of the industry. Some such as Bohemia and Pope & Talbot engage primarily in the cutting of timber on public lands. Others such as Fort Howard Paper, Garden State Paper, Alton Box Board, Fiberboard, and Federal Paper Board, use as primary inputs wastepaper generated from post consumer and industrial conversion waste.

Capital intensity in production is highest for the large diversified firms and least for the scrap users. According to Fortune, assets per employee for four of the diversified firms including Weyerhaeuser, Georgia Pacific, Boise Cascade, and Potlach Forests averaged over $49,000 in 1973. For a group of nine paper companies, capital per worker averaged $41,700, while for the firms using wastepaper it averaged $32,700. This compares with the average for all manufacturing of under $30,000.

According to computations by Fortune, the rates of return to equity invested in the wood product industry have been below the average for the 500 largest manufacturing concerns for most of the last decade. When rates of return are separated into those classified by Fortune as paper companies and those classified as large diversified forest product companies, a significant difference emerges. The large forest product companies have consistently earned higher than average returns (with the exception of Boise Cascade whose ill fated venture into real estate caused large losses in 1971 and 1972), while the paper companies have experienced excess capacity and low rates of return throughout the 1960's and into the early 1970's. Recently demand has caught up with capacity and rates of return to paper companies are improving. Table 5-2 presents some of this data.

In searching for an explanation of the difference in rates of return for these two groups, it should be asked if the difference is real or merely the result of some form of measurement error. One likely explana-

Table 5-2. RATES OF RETURN TO EQUITY IN PAPER AND FOREST PRODUCTS INDUSTRY

International	Mead	Crown Zellerbach	St. Regis	Kimberly Clark	Scott	Weyerhaeuser	Georgia Pacific	Diamond International	Fortune's Paper & Wood Prod. Ave.	500 Industrial Average	YEAR
3.7	7.9	10.0	6.4	9.4	12.3	11.5	13.4	13.0			1964
9.1	8.6	9.9	8.2	8.9	12.7	13.2	12.4	15.3			1965
10.3	9.8	10.7	8.4	9.4	11.4	12.0	12.4	16.0		12.7	1966
8.4	6.9	9.6	6.4	9.9	10.2	9.1	11.8	14.7	9.0	11.3	1967
9.2	7.5	11.0	7.0	9.2	10.8	14.7	13.8	14.2	10.0	11.7	1968
10.3	8.0	9.6	7.8	7.2	11.5	13.9	14.7	13.9	10.5	11.3	1969
7.5	4.5	7.4	6.7	8.4	9.1	12.2	11.8	12.9	6.8	9.5	1970
5.0	5.2	5.3	3.4	-	5.1	9.6	12.0	12.6	5.6	9.1	1971
9.2	4.0	6.0	7.6	13.7	7.1	14.1	15.9	12.5	8.6	10.3	1972
13.5	10.8	15.6	10.5	13.4	9.8	25.1	21.0	14.0	13.5	12.4	1973

Source: Fortune, various issues, and corporation annual reports.

tion, noted in an earlier chapter, is that land used for production of timber is presently worth substantially more than its book value. Land at its original acquisition cost is included in the asset base for rate of return calculations. If land values are adjusted to reflect current market prices, the high rate of return for the forest product companies, as compared with general manufacturing, would probably disappear. Another possible explanation for the difference between the two groups is that those classified as integrated concerns utilize wood more fully. Given large transportation costs in proportion to product value, it is likely that non-integrated concerns are offered low or zero prices for wood residues and scraps. Users of the residues are able to obtain inputs more cheaply from nearby sources.

IV. THE EFFECTS OF NON-TAX FEDERAL POLICIES ON TIMBER SUPPLY

This section reviews certain non-tax federal timber policies as they affect the supply of stumpage from public lands. Federal lands supply a relatively small portion of total stumpage, because they constitute a small percentage of total acreage (Table 5-3) and the federal lands are relatively low in productivity (Table 5-4).

Retention of lands of particular national importance in federal ownership began with the legislation creating Yellowstone National Park in 1872[11]. The growing interest in conservation in that era produced at least two significant pieces of legislation that have profoundly affected domestic forest policy, the Forest Reserve Act of 1891[12] and the Forest Service Organic Administration Act of 1897.[13] Presidents Harrison, Cleveland, McKinley and Roosevelt utilized the executive authority conferred by the 1891 Act to withdraw millions of acres of public timber lands from disposal under earlier statutes. The Forest Service Organic Administration Act of 1897 provided the basis for the establishment of the present system of national forests which now encompass some 187 million acres, 91 million of which are forested, in 155 national forests in 40 states.

Table 5-3 OWNERSHIP OF COMMERCIAL TIMBERLAND

Type of Ownership	Total United States Area	Total United States Proportion	North	South	Rocky Mts.	Pacific Coast
	Thousand Acres	Percent	Thousand Acres	Thousand Acres	Thousand Acres	Thousand Acres
Federal:						
National Forest	91,924	18	10,458	10,764	39,787	30,915
Bureau of Land Management	4,762	1	75	11	2,024	2,652
Bureau of Indian Affairs	5,888	1	815	220	2,809	2,044
Other Federal	4,534	1	963	3,282	78	211
Total Federal	107,109	1	12,311	14,277	44,699	35,822
State	21,423	4	13,076	2,321	2,198	3,828
County and municipal	7,589	2	6,525	681	71	312
Forest industry	67,341	14	17,563	35,325	2,234	12,219
Farm	131,135	26	51,017	65,137	8,379	6,602
Miscellaneous private	165,101	33	77,409	74,801	4,051	8,840
All ownerships	499,697	100	177,901	192,542	61,632	67,622

Source: U.S.D.A., The Outlook for Timber in the United States, FRR-20, July 1974.

TABLE 5-4. AREA OF COMMERCIAL FOREST LAND BY OWNERSHIP CLASSES AND SITE QUALITY

(Areas in Million Acres by Site Classes)[a]

Ownership class	I	II	III	IV	V	All site classes
National forest	2.9	8.5	17.6	32.7	25.2	86.9[b]
Other public	2.0	3.5	6.0	16.7	16.0	44.2
Forest industry	4.1	8.0	18.8	24.9	11.5	67.3
Other private	4.4	18.0	73.8	121.2	78.8	296.2
All ownerships	13.4	38.0	116.2	195.5	131.5	494.6[b]

[a] Site class I to V refer respectively to lands capable of producing growth of 165-plus, 120-165, 85-120, 50-85, and 20-50 cubic feet of timber per acre per year.

[b] Estimates of area subclasses do not include 5.0 million acres of national forest lands in the Rocky Mountain States that are not included in the base for allowable cut because of such factors as unstable soils, small size of isolated patches and stringer, or special use constraints. Volume and growth data are also excluded for these areas.

Source: U.S.D.A., The Outlook for Timber in the United States, FRR-20, July 1974.

Unappropriated and unreserved lands of the United States are administered by the Bureau of Land Management of the Department of the Interior and total some 470 million acres principally in the eleven western states and Alaska. Following its creation[14] in 1946 from a merger of the old General Land Office and the Grazing Office, the Bureau of Land Management obtained a clearly defined mandate from Congress in the Classification and Multiple-Use Act of 1964[15] which provided for multiple use objectives similar to those of the Forest Service Organic Administration Act, and the later Multiple-Use and Sustained-Yield Act of 1960[16] which directly affects Forest Service harvesting policy.

Land held by various state and local agencies was primarily obtained by confiscation for non-payment of property taxes during the 1930's. There does not appear to be any explicit policy directing land use decisions on most of this acreage, although some states (especially Washington) have discovered state-owned forest lands as a source of revenue and manage forest lands well.

That private timber holdings, especially those under control of the forest industry, dominate other categories in importance as a source of supply, becomes abundantly clear when one considers the ownership and productivity of the various forest lands. Commercial timber land is defined by the U.S. Department of Agriculture to be land capable of yielding 20 or more cubic feet of new growth per acre per year. According to a recent study a large portion of the best sites yielding in excess of 85 cubic feet per acre per year are in forest industry ownership, while holdings by public agencies in national forests and elsewhere have a high proportion of sites with the potential for less than 50 cubic feet per acre per year.[17]

It has always been the avowed policy of the Forest Service to permit a wide variety of compatible uses in the national forests. This policy was formalized in the Multiple-Use and Sustained-Yield Act of 1960. This Act does not specify any priorities among competing uses, leaving the determination of appropriate use to be decided on a case by case basis. Before considering the complications that arise when one considers multiple use, it is convenient to examine public policy and private decision making regarding the choice of harvesting technique of public lands.

Although timber is frequently cited as one area where astute practices on both the governmental and private level have led to an increase in the resource base, while simultaneously satisfying demands for current use of the resource, there is a sharp divergence of opinion as to whether or not we have enough timber for the future. The relative uncertainty of timber inventories held by the industry, and additional uncertainties associated with estimates of future growth rates following various harvesting practices, combine to make forecasting difficult. In a recent report the Forest Service argues that demands are indeed growing more rapidly than forests can be regenerated, and that unless prices for forest products rise rapidly in the near-future severe shortages are to be expected. (See The Outlook for Timber in the United States. Forest Resource Report No. 20.) The balance between removals and new growth is presented in Table 5-5. It indicates that for 1970, removals were comfortably surpassed by growth for all species except softwoods in the Pacific Coast. In this area a special consideration prevails in that much of the forest has never been harvested. Under more intensive harvesting and management it is thought that its yield could be substantially increased.

When the balance between growth and removal is considered for the category of dimension lumber (sawtimber), the optimistic pattern starts to fade. Historically, removals mainly consisted of mature trees, for relatively large trees were required for dimension sawing. Growth predominates in smaller trees, which are not cataloged as sawtimber until they reach a diameter of 11 inches. The Forest Service has argued that at present

Table 5-5. NET ANNUAL GROWTH AND REMOVALS OF GROWING STOCK, BY SPECIES GROUP AND SECTION[a]
(Billion Cubic Feet)

Section	All species			Softwoods			Hardwoods		
	1952	1962	1970	1952	1962	1970	1952	1962	1970
North:									
Net growth	4.1	4.9	5.5	1.1	1.2	1.4	3.0	3.6	4.2
Removal	2.1	2.5	2.4	.6	.6	.6	1.5	1.5	1.8
Ratio of growth to removals	2.0	2.5	2.3	1.7	2.2	2.2	2.1	2.4	2.3
South:									
Net growth	6.3	7.5	8.6	3.6	4.5	5.4	2.7	3.0	3.2
Removals	5.7	5.4	6.5	3.1	2.8	4.0	2.6	2.6	2.5
Ratio of growth to removals	1.1	1.4	1.3	1.2	1.6	1.4	1.1	1.1	1.3
Rocky Mountains:									
Net growth	1.2	1.3	1.4	1.1	1.2	1.3	.1	.1	.1
Removals	.5	.7	.0	.5	.7	.9	b	b	b
Ratio of growth to removals	2.2	1.8	1.5	2.1	1.7	1.4	21.9	18.9	26.2
Pacific Coast:									
Net growth	2.3	2.7	3.1	2.0	2.3	2.6	.3	.4	.5
Removals	3.5	3.6	4.2	3.5	3.5	4.1	b	.1	.1
Ratio of growth to removals	.7	.8	.7	.6	.7	.6	6.7	4.9	4.1
Total, United States:									
Net growth	13.9	16.4	18.6	7.8	9.3	10.7	6.1	7.1	7.9
Removals	11.8	11.8	14.0	7.8	7.6	9.6	4.1	4.2	4.4
Ratio of growth to removals	1.2	1.4	1.3	1.0	1.2	1.1	1.5	1.7	1.8

a Data may not add to totals because of rounding.
b Less than 1 billion.

Source: U.S.D.A., The Outlook for Timber in the United States, FRR-20, July 1974.

removals exceed growth in the Rocky Mountain and Pacific Coast Regions, and for the nation as a whole. The forest industry has countered this evidence with the observation that "the Forest Service has been predicting a shortage ever since it began, and it hasn't happened yet."[18] They also feel that because trees as small as 4 inches in diameter are currently being used for dimension sawing, the Forest Service inventory of growth is biased downwards. Under more intensive management, including shorter growth cycles, the industry anticipates significant supply increases not forecast by the Forest Service.

Even if corporate projections of substantial increases in timber supply from lands held by the forest products industry are achieved, the total future supply of timber may change but little due to court imposed restrictions on harvesting techniques in National Forests. In the decision, West Virginia Division of the Izaak Walton League v. Butz, the Fourth Circuit Court of Appeals upheld a lower court ruling that the Organic Act of 1897 (16 U.S.C. §§ 473-482, 551) bans clearcutting on federally owned land in the Monongahela National Forest. Of the four principal systems of harvesting timber (the clearcut, seed tree, shelterwood, and selection systems), clearcutting is considered by the timber industry to be the least costly, and most beneficial to the establishment of a new crop. At the same time clearcutting also results in the most radical alteration in the forest environment.[19]

Should the decision in the Monongahela National Forest be extended by other courts to cover the remaining national forests, the costs of obtaining timber from public lands will rise substantially. This would have the effect of reducing the public lands component of the timber industry supply curve.

CHAPTER 5

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CHAPTER 6

THE EFFECTS OF TAXATION ON VIRGIN MATERIAL PRICES

This chapter examines the impact of a variety of taxes and tax subsidies on the price of virgin material outputs. The price impacts are computed for the virgin material product which competes most closely with scrap materials as an input to further production processes. For example, scrap steel is most often viewed as a substitute for pig iron in many steel manufacturing processes. Consequently, the impact of corporate taxation on the price of pig iron, rather than other iron-based products, will be of most interest to us here.

Part one of this chapter examines the impact of net and gross income taxes, as well as expensing provisions for mineral exploration and development and severance taxes on the supply schedule for virgin material outputs. In part two the impacts of various taxes on the price of semi-manufactured virgin based products (such as pig iron) are computed. It begins with a discussion of the assumptions underlying the calculation of price effects and continues with specific analyses of the paper, steel, copper, lead, and aluminum industries.

I. THEORIES OF TAX INDUCED SHIFTS IN SUPPLY

A. Income Taxation

It is generally agreed that a tax on the profits of a monopoly leaves unaffected the position of the short run marginal revenue and marginal cost schedules. Hence a tax on profits does not change the position of profit maximizing output. Only if a monopolist was not previously maximizing profits would one expect to observe a short run price increase. In the long run a tax on profits could in effect become tax on capital (if at least a normal return was not being earned). This would change marginal cost and hence profit maximizing output.

A tax on the economic profits (profit after allowing for all costs including normal return to capital) of pure competition would produce no revenue, because there are no economic profits associated with pure competition. As such it would have no effect on price or quantity. But the corporate income tax is levied not only on economic profit, but also on the normal return to capital. As Robertson[1] and others have argued, the normal profit component is included in the cost schedule of a firm and thus a tax on normal profits is a tax on cost. If the tax is on all capital the supply of capital may be curtailed. If the tax is partial and affects only a few firms or industries, firms will leave the industry subject to taxation and move into fields not subject to taxation until returns net of tax are equalized.

Harberger[2] and Mieszkowski[3] have argued that, under some very general assumptions, an income tax is born by the single factor of production, capital. The extent to which a tax on one factor will induce substitution among inputs depends on the elasticity of substitution - the percentage of change in the ratio of factor use in response to a one percent change in the ratio of factor prices. Several studies have attempted to estimate elasticities of substitution for different industries, but the reported results for individual industry classifications exhibit extreme variation. (For example, Blair and Kraft[4] estimated the elasticity of substitution for lumber to be 1.3 and for iron and steel foundries .50. Unfortunately, their report does not contain estimates for the industrial classifications discussed in this report.) Estimation of the impact of income taxes on the industry supply curve depends critically upon knowledge of the elasticity of substitution, and until better estimates are developed further progress along these lines is virtually impossible.

If one is willing to assume the magnitude of the elasticity of substitution, it is possible to estimate the impact of income taxation on supply. Consider for example the unitary elasticity of substitution as embodied in the Cobb-Douglas production function. The supply curve (marginal cost curve) for a firm in pure competition can be derived from (1) the production function, (2) the cost equation, and (3) the expansion path. It can be shown that marginal cost for a given level of output depends on the cost of capital raised to the power'b', where 'b' is capital's share in the output.*

A further complication encountered in attempting to trace the impact of a change in income tax rates on the industry supply curve results from the unpredictable manner in which income taxation affects the cost of capital. Income taxes are levied on accounting profits - which are merely the return to equity capital. Tax liability for the return on borrowed capital is reduced by the amount of the interest paid on the borrowed capital. A change in the rate at which the return on equity

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* From (1) $Q = L^a K^b$

(2) $C = wL + rK$

(3) $\frac{wL}{a} = \frac{rK}{b}$

it is easy to show that $C = r^b Q(a/bw)^{-a}$, provided constant returns to scale, or $a + b = 1$. Marginal cost is given by:

$$\frac{dC}{dQ} = MC = Ar^b$$

where A = the constant $(a/bw)^{-a}$

capital is taxes induces a substitution between debt and equity that is difficult to predict, hinging as it does on attitudes toward financial riskiness of the capital structure.

The inability to predict factor substitution in response to shifts in relative factor prices precludes accurate analysis of marginal costs of production when income tax rates are changed. Though precise derivations are impossible, one can compute the maximum possible impact, which is obtained when the elasticity of substitution is zero. For this situation, a change in relative factor prices induces no changes in factor proportions. This assumption overstates the impact on cost when the price of a single factor is increased (because of substitution which ordinarily would occur toward the factor whose price remained fixed), but understates the impact when the price of one factor is reduced (because even more would be used as substitution toward that factor takes place). Later in this chapter we develop estimates of the impact of capital gains taxation on the supply curve for virgin woodpulp, based on the assumption of zero elasticity of substitution of capital for labor. These estimates are based on what would happen to the existing supply curve, which reflects capital gains treatment of stumpage profits, should capital gains be disallowed in the future. As noted, this will overstate the upward shift in the supply curve to the extent there is substitution among inputs.

B. Taxes on Gross Income

Two special tax provisions for mineral industries are based on gross income; percentage depletion and severance taxes. The depletion allowance serves to exempt from income taxation a percentage of gross revenues. As such it serves as a subsidy in the amount of the tax that would have been paid on this income. Severance taxes are typically levied by states and are set as a percentage of the value of output. Taxes that are based on the value of output are termed ad valorem taxes (or subsidies in the case of percent depletion).

The algebraic equivalence between severance taxes (or excise taxes) and a depletion allowance can be demonstrated.

Let R = Revenue

C = Cost

t = Income tax rate

s - Severance tax rate

d - Rate of percent depletion

After-tax profits with severance taxes $(1-t)(R-C-sR)$, equal after-tax profits with a depletion allowance, $R-C-t(R-C-dR)$ when the 50 percent of net income limitation requires that $dR \leq (R-C)/2$..

The adjustments of competitive and monopolistic industries to ad valorem taxes and subsidies are depicted in Figure 6-1, panels A and B. The competitive industry supply schedule before the imposition of an ad valorem tax is S-S; it intersects the market demand curve to produce an equilibrium price of P_o. A tax of T per dollar raises the supply curve to S'-S', and the corresponding market price is P'. The relationship between the change in price and the tax is: $\Delta P = TE_s/(E_s + E_d)$,* where E_s and E_d refer to the elasticities of supply and demand respectively.

The monopolistic case is depicted in Panel B. Here an ad valorem tax of T per dollar shifts marginal cost from MC to MC' and market price from P to P'. The change in market price can be estimated if one knows both the slope and intercept of the demand curve (from which the marginal revenue can be determined) as well as the marginal cost curve for the firm. Inasmuch as none of the industries studied are organized as monopolies, further analysis of this model will not be developed.

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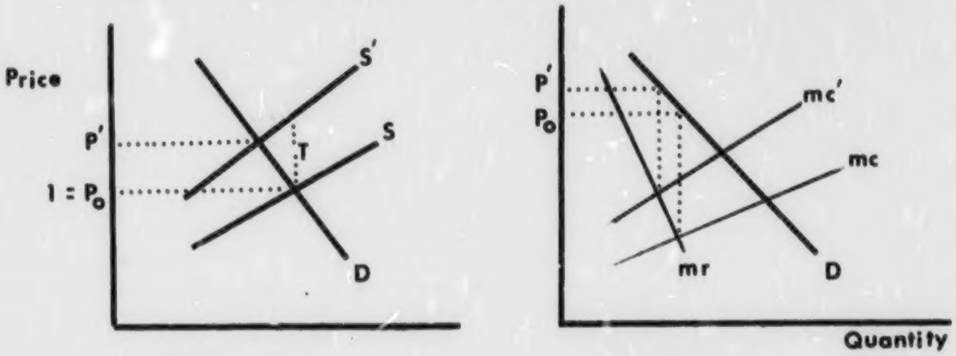
* Let D_1 represent the slope of the demand curve and S_1 represent the slope of supply. Then $\Delta P = \Delta Q$, where ΔQ is the reduction in quantity as a result of the tax. Similarly we may calculate $\Delta P = T(D_1 \Delta Q)/(D_1 \Delta Q + S_1 \Delta Q)$, since T is just $D_1 \Delta Q + S_1 \Delta Q$. Substituting $E_d = (P/Q)D_1$ and $E_s = (P/Q)S_1$ we obtain the above result.

Figure 6-1. EFFECTS OF AD VALOREM TAXES ON MARKET PRICE



PANEL A PANEL B

As noted earlier a depletion allowance is equivalent to a negative excise tax, provided the 50 percent of net income limitation has not been exceeded. This means that if the portion of market price attributable to the allowance, (T/P'), can be determined the percentage change in market price which results from elimination of the allowance is obtained directly as:

$$\frac{\Delta P}{P'} = \frac{(T/P')\ E_s}{E_s + E_d}$$

The impact of the percent depletion allowance on the supply of domestic mineral output deserves a more careful scrutiny. As noted in Chapter 2, depletion deductions are limited to half of net income from an operating unit. This in turn means that there will be, in general, two different effects depending on the profitability of an operating unit. For those units which are not constrained by the 50 percent of net income limit, profit margins on sales are in excess of twice the rate of percent depletion. One would expect that when profit margins are this high production has already been pushed about as far as possible and the depletion deduction would make little difference on output.

As Miller has noted, percent depletion should affect the profitability and hence output decisions for marginal operating units which are constrained by the 50 percent of net income limit. Because production costs are only slightly below output price, a change in the income tax rate would have a significant influence on output decisions for many of these units. With the corporate income tax rate at 48 percent, the effective income tax rate on investment in marginal production is 24 percent (half of income is sheltered from taxation). This indicates that the required pre-tax rate of return has been reduced from approximately 14.8 percent (the average for 1969) to 10.1 percent for the marginal mining operations, so that the marginal mining units would offer 7.7 percent after taxes, the average for all corporations (in 1969).

Assuming a capital-output ratio of about 2.0 in metal mining, the supply curve for metals would be shifted downward by approximately 9.4 percent by percent depletion. (14.8 percent - 10.1 percent = 4.7 percent of capital costs, which are then multiplied by the capital-output ratio of 2.0 to obtain the 9.4 percent impact on the supply curve of the marginal producers.)

C. Expensing of Exploration and Development

The income tax provisions under which mining firms may treat as a current expense non-depreciable exploration outlays designed or intended to locate and define the extent of mineral properties were discussed in Chapter 2. In many respects this deduction is remarkably similar to one not only allowed, but now mandated by generally accepted accounting principles, for manufacturing concerns which engage in research and development. Outlays for research and development are expensed as incurred, resulting in an immediate reduction in tax liabilities, even though the research is likely to enhance the long run value of the firm. The deduction is subject to recapture in the future to the extent that profitable discoveries evolve from the research program.

At the election of the taxpayer mineral exploration for the purpose of "ascertaining the existence, location, extent, or quality of any deposit" may be deducted against current income or added to the adjusted basis of the mineral sites.[5] In practice, expensing of exploration is normally far more favorable in tax impact than is capitalization - principally because percent depletion would be lost as an option should the firm assess exploration outlays to the cost, or adjusted, basis and recover them through cost depletion. If any mine for which exploration outlays were previously expensed reaches the producing stage, the deductions are recaptured through reductions in depletion deductions that may be taken, or through the addition of the outlays to taxable income.

Tax treatment of exploration expenditures which are added to the adjusted bases and recovered through cost depletion is remarkably similar to the treatment of investment in plant and equipment, the closest counterpart in manufacturing. In manufacturing a firm recovers investment outlays gradually through depreciation deductions against taxable income.

The tax treatment of exploration which is expensed and later recaptured has the counterpart of successful research endeavors in manufacturing. Outlays which are expensed and later recaptured result in no net deduction, but do alter the timing of tax payments. In contrast, outlays which are added to the adjusted basis and then recovered through cost depletion do result in a net deduction, but the timing is not so favorable. In principle, a mining firm must choose between a substantially improved timing of tax payments with no net reduction in taxes, and a net reduction in taxes - but only in future years. This simplistic view requires one major modification. A firm electing to take cost depletion on a property may not simultaneously obtain the benefits of percent depletion. Because percent depletion is normally so favorable in impact, firms probably are induced to expense more than they would like, and capitalize less than they would like, just to be able to utilize the percentage depletion deduction.

Development expenditures incurred after the existence of ores or minerals in commercially marketable quantities has been ascertained may be deducted from taxable income in the year in which they occur. Alternatively, development expenditures may be deferred for deduction against income in future years. The deferral of development deductions is rational corporate policy when income would otherwise be reduced to the extent that percent depletion deductions would be constrained by the 50 percent of net income limitation.

The tax treatment of development expenditures has no counterpart in manufacturing. It is much as if investments in plant and equipment could be depreciated within one year - the tunnels and shafts in mining corresponding to buildings in manufacturing.

The Treasury Depletion Survey of 1958-1960 provides the only comprehensive data on tax treatment of development expenditures. It is apparent from Table 6-1 that most development expenditures are immediately expensed - but a considerable fraction is also deferred. Only for lead and zinc are the quantities capitalized significant.

Table 6-1. DEVELOPMENT EXPENDITURES 1960
(Percentage Distribution by Tax Treatment)

Mineral Product	Deducted as Current Expense	Charged as Deferred Expense	Charged to Depletable Asset Account	Charged to Depreciable Asset Account
Bauxite	100.	-	-	-
Lead & Zinc	43.2	10.4	9.8	36.7
Iron	99.8	-	-	.2
Copper	62.9	36.7	-	.4
Limestone	51.9	40.4	7.5	.2
Anthracite	92.7	7.3	-	-

Source: President's 1963 Tax Message

The Treasury Survey also allows direct comparison of current deductions for exploration and development with the magnitude of the depletion subsidy (depletion taken in excess of actual cost depletion).

Table 6-2. DEDUCTIONS FOR EXPLORATION AND DEVELOPMENT

Mineral	Percent of Depletion in Excess of Cost Depletion
Metal Mining	41%
Primary Metal Manufacturing	49%
Bituminous Coal	28%
Stone, Clay and Glass	14%

Source: President's 1963 Tax Message

An attempt to update the 1960 Treasury Survey to obtain figures on expensing for 1973 failed because corporations are not, under present SEC regulations, required to report any class of expenditure aggregating less than 1% of sales revenue. Those firms reporting mineral exploration outlays separately are listed in Table 6-3 along with depletion and exploration amounts as a percent of pre-tax income. For this sample exploration is about one-third of depletion.

Table 6-3. MINERAL EXPLORATION OUTLAYS

Firm	Depletion as Percent of Pre-Tax Income	Exploration as Percent of Pre-Tax Income
Bethlehem Steel		
1973	7.3	2.3
St. Joe Minerals		
1973	20.8	7.1
1974	22.9	3.8
Phelps Dodge		
1973	18.8	4.9

Source: Derived from Corporation 10-K Reports

D. Severance Taxes

Severance taxes on mineral output are levied by many states. Functioning directly as excise taxes, the severance taxes serve to reduce the favorable impact of percent depletion. Some severance taxes are levied on unit weight, others are based on the value of output at the mine, and still others are based on the value at a higher stage of processing, or on gross income. Such variation makes generalization of the impacts difficult.

Only two of the mining firms in the survey of Chapter 3 reported state severance taxes separately from other taxes. For Kennecott Copper severance taxes in the amount of $14.44 million in 1973 amounted to 22 percent of the reduction in income taxes attributable to percent depletion. For AMAX state severance taxes of $4.17 million were 20 percent of the reduction in income taxes attributable to percent depletion.

Some examples of state severance taxes are:

Idaho	2% of value of ores mined
Kentucky	4% of value of coal mined
Minnesota	15 1/2% of value of iron ore mined
	15% of value of taconites mined
Arkansas	15 cents per ton of bauxite mined

Bauxite mined in Arkansas was worth about $14.00 per ton making the severance tax slightly over one percent of value. The percent depletion allowance, by way of comparison, excluded 22 percent of value from taxation at the rate of 48 percent, and represented a negative excise tax of .48 X 22 percent = 10.6 percent - or about ten times the amount of the severance tax.

II. ANALYTICAL MODELS OF TAXATION AND RESOURCE USE

The analysis of tax induced shifts in the supply curve for virgin material inputs theoretically would involve the comparison of market equilibria, before and after the tax change, in the product market as well as in the factor markets for virgin and scrap inputs. The relationships may be depicted as follows:

Product Market
Demand = F_1 (Price of Output, Income, Other Prices)
Supply = F_2 (Price of Virgin Input, Price of Scrap Input, Prices of Other Inputs).

Virgin Input
Demand = F_3 (Price of Output, Price of Virgin Input, Price of Scrap Input)
Supply = F_4 (Virgin Availability, Processing Costs)

Scrap Input
Demand = F_5 (Price of Output, Price of Scrap Input, Price of Virgin Input)
Supply = F_6 (Scrap Availability, Processing Costs)

A change in taxation of virgin extractive industries would shift the virgin input supply curve. The accompanying change in virgin input prices would shift the supply curves in both the scrap input market and in the market for final outputs. Prices for final output and scrap inputs would change, and these changes in turn would induce a second round of adjustments in the virgin input market. The ultimate equilibrium situation in virgin and scrap input markets is only approximated by the first round of adjustments. Because the tax changes considered later will typically involve removal of a subsidy - thereby shifting virgin input supplies upward - the supply for final outputs will also be shifted upward. A lower production of final outputs will ensue and tend to lower the demand for both scrap and virgin inputs - and thus the equilibrium impact on virgin input prices normally will be less than that indicated in the first round of changes. Similarly the demand for scrap should rise somewhat less than predicted by estimated cross elasticities multiplied by the first order effects in virgin input prices, both because less final output is being sold and because the change in virgin input prices was over-estimated.

In the remainder of this section the magnitude of the shift in the supply curve for virgin materials is analyzed. Removal of tax benefits which affect the cost of a single factor of production would be expected to elicit substitution among inputs, but in the analysis to follow such substitution is assumed to be negligible. Consequently, the estimated supply curve shift for pulpwood, should capital gains be denied in the growing and harvesting of timber, may be biased upward. For tax benefits which affect gross income, such as the depletion allowance and severance taxes, substitution among factor inputs would also be expected to lower the shift in supply from that computed here.

A. Paper

Standing timber, or stumpage, is harvested, converted to wood chips, and dissolved into woodpulp, before manufacture into paper products. Wastepaper. the scrap industry's input to the production of paper products, is processed and converted to a pulp before manufacture into paper products. Wastepaper probably substitutes most directly for virgin market pulp as an input, though the technical relationships are quite complicated (See the section on paper in Chapter 9).

The maximum impact of capital gains taxation on the price of virgin market pulp is obtained under the assumptions that stumpage costs are negligible so that all of stumpage price is profit, and the supply curve for stumpage is elastic so that taxes on inputs are passed forward onto product price rather than backward onto land rents. The cost of acquiring stumpage may be negligible for timber owners who wait for seedlings to mature - especially since many of the costs of timber management are deductible against current income. An elastic supply of land for the production of timber implies that a tax imposed on the growing of timber will cause changes in land use until timber is once again as profitable as other competing uses. That is, the supply curve for stumpage will shift vertically by the amount of the tax.

It should be noted that the maximum impacts of changes in timber tax policy are achieved only when sufficient time has elapsed to attain equilibrium. Though land values would be expected to reflect changes in tax policy almost immediately, the impact of taxation on timber supply would be very gradual. For example, the 1944 extension of capital gains treatment to long term profits on stumpage processed by integrated timber firms certainly made the growing of timber more attractive relative to alternative uses for many lands. This would be reflected in an enhancement in the value of those lands for which timber became the most valuable crop as a result of the change in the tax code. Though the impact on timber plantings may have been felt shortly after passing of the legislation, the impact on timber harvests probably has not yet been felt as it takes anywhere from 20 to 80 years for a tree to reach the date at which profits are maximized by harvesting it.

Likewise, if stumpage profits were subjected to ordinary rates of income taxation rather than the preferential capital gains rates, the full impact of timber prices and supply would not be felt for many years. In analyzing the impacts it is useful to separate timber lands into two categories: those for which the growing of timber is the highest and best use under both systems of taxation, and those whose best use changes from timber to an alternative activity as income tax rates are increased. Only on the latter lands, which we will term marginal for timber supply, will taxation affect supply. On the marginal lands an increase in tax rates will create incentives to liquidate timber holdings to facilitate the switch to alternative land uses. Thus, in the short run, timber supplies may be augmented by elimination of capital gains treatment of stumpage profits. In the long run, of course, supplies will be diminished as a consequence of the loss of output from the marginal lands.

If the long run supply of timber is indeed elastic, and if all of stumpage value is capital gain, the maximum long run impact of capital gains taxation on the price of stumpage would be 34.6 percent. (Under capital gains treatment, a unit of land, yielding timber worth $1.00 before taxes and $.70 after taxes, would have to yield $1.346 before taxes at the normal corporate rate of 48 percent to produce the same $.70 after taxes.) Historical transactions indicate that stumpage prices have averaged between 6 and 12 percent of market pulp prices.[6] This indicates that the maximum long run impact of capital gains taxation on market pulp prices would be 4.2 percent. (The 4.2 percent is obtained by multiplying 34.6 percent by 12 percent.)

Three factors indicate that 4.2 percent is an over-estimate of the impact of capital gains taxation on market pulp prices. First, it was assumed that there would be no substitution between factors in response to a change in the cost of one factor. The elimination of capital gains treatment for timber would raise the cost of capital and would be expected to induce some substitution of labor for capital. To an unknown degree this would reduce the impact of the elimination of the tax subsidy. Second, 100 percent of stumpage value is assumed to be capital gains income, even though some widely quoted sources have indicated a figure of 50 percent is more appropriate.[7] Third, the long run supply curve for stumpage was assumed to be infinitely elastic, yet one study located in the literature survey indicated that the best estimate of long run supply elasticity of Douglas-fir timber is only .1. If the more pessimistic assumptions are used the long run price impact could be as little as 0.1 percent, and the intermediate and short run impacts could well be nil.

B. Mining

The standard analysis of corporate taxation presented earlier in this chapter is not directly applicable to the mining industry. Unlike manufacturing new mining firms cannot obtain all inputs at constant cost. The supply of mineral deposits, in particular, is an increasing function of mineral prices. In addition, the owner of an operating mine must consider the impact of current production on the profits which could have been earned in later periods had production been delayed. In these respects, the standard analytical models of corporate taxation must be modified before they may be applied to the mineral industry. Existing work on theories of the mine and mining has assumed complete knowledge of the extent of ore reserves and the future course of taxation and mineral prices. The ability of such models to yield correct predictions to questions of taxation and the course of resource supplies over time is certainly open to question given the strong assumptions incorporated in model development. Nonetheless, we will briefly outline some of the existing theoretical models in the hope light will be shed on issues of interest to this report.

Hotelling's original work in the theory of exhaustion has been extended and generalized by Schulze[8] and Peterson[9] to allow for entry and exit of mining firms, externalities and taxation. In this section the notation will parallel that used by Schulze. It is assumed that all mineral deposits are known and are of uniform quality, and that mining firms operate in a world of perfect certainty. It is further assumed that mining firms are free to enter the industry and bid for the right to extract minerals from the known deposits. Firms may leave the industry at any time by selling their remaining rights to existing firms in the industry.

The notation to be used is as follows:

$q(t)$ = output of each firm (all are assumed identical at time, t)
$n(t)$ = number of firms
$p(nq)$ = price as a function of industry output

$B(nq)$ = benefits (willingness to pay for industry output)

$C(q)$ = long run cost function for firms

$\bar{X}$ = stock of the resource available for exploitation

r = social rate of discount (assumed equal to the competitive interest rate)

Pareto optimality is achieved by maximizing the present value of the net benefits for the entire industry,

$$\int_{t=0}^{\infty} \left[e^{-rt} B(nq) - nC(q)\right] dt$$

subject to the constraint on resource availability,

$$\int_{t=0}^{\infty} nq \; dt \leq \bar{X}.$$

This problem in the calculus of variations can be solved by introducing the Lagrange multiplier, λ, and maximizing

$$\int_{t=0}^{\infty} \left[e^{-rt} (B(nq) - nC(q)) - \lambda nq\right] dt$$

by using the Euler conditions to determine $q(t)$, and a terminal condition to obtain the optimal period of extraction. The principal conclusions are twofold (the interested reader is referred to Schulze for the derivations):

1. price equals marginal cost plus an imputed cost of the resource expressable as the present value of foregone future profits;
2. the number of firms declines to zero as the terminal date of exhaustion is approached.

Hotelling was the first to demonstrate that a competitive extractive industry, wherein each firm attempted to maximize the present value of its profits, would satisfy the conditions for Pareto optimum. Of course, the presence of externalities, as would occur if benefits depended on the stock of resources left untouched by the extractive industry as well as the cumulative output of the industry, would mean that the competitive extractive industry would no longer achieve the conditions of Pareto optimality. This problem, as well as the problem of recycling extracted resources, has been discussed by Schulze.

The models developed by Hotelling, Schulze, and Peterson do have implications for the impact of taxation on mineral industry supply curves. In general, they demonstrate that simple taxes and subsidies alter the optimal time path of production as well as being passed both forward into product prices and backward into land rents. Without a detailed specification of the availability of deposits of varying grades it would be impossible to predict tax incidence. Similarly, without complete knowledge of future mineral prices, the impact of taxation on intertemporal production paths is impossible to predict accurately. In the following individual industry analyses we assume the full magnitude of various taxes and subsidies are passed forward onto final product prices. Also, having no real basis for predicting the impact of taxation on the time path of production, we chose to assume the net impact of uncertainty and all forms of taxation is neutral with respect to the timing of production.

1) Copper

Most United States primary copper is obtained through open pit mining of extensive porphyry copper deposits in the Western States. The copper content of ores presently mined averages between .6 percent and .9 percent copper, or some 12 to 18 pounds per ton. Though most metals have fallen in real price over the last several decades, due primarily to rapid technological progress in mining and processing, the real price of copper has increased - a phenomenon that has been attributed to a persistent decline in the average grade of ore available for mining.

The cutoff grade is the designation of ore which contains just enough metal to permit further processing at a break even level of profitability. At the mine site copper ore is physically separated from waste (ore below the cutoff grade) and shipped to concentrating plants. Beneficiation of copper generally includes crushing, grinding, classification, flotation, and filtration and results in copper concentrates containing 11 percent to 38 percent copper. Between 10 percent and 15 percent of domestic mine output of copper is obtained by leaching low grade waste material with a dilute solution of sulfuric acid. In several leaching operations large quantities of post-consumer steel cans are used as a source of iron to accelerate the process.

Iron and sulfur impurities in copper concentrates are removed through the separate processes of roasting, which is used to regulate the sulfur content; smelting, which eliminates most of the impurities and yields a product termed blister copper; and final purification through fire refining or electrolytic refining.

The significant tax provisions affecting the copper industry are percent depletion, expensing of exploration and development, the foreign tax credit, the investment tax credit, and severance taxes. These will be considered in turn.

Percent depletion is allowed on the value of copper concentrates at the rate of 15 percent for both domestic and foreign production. Copper concentrates are not traded on any established market and their value for tax purposes is obtained by allocating costs to other operations (especially smelting and refining) and treating the residual as the value of concentrates. The Bureau of Mines has estimated that smelting costs are about 4 cents per pound, refining costs about 6.4 cents per pound, and pollution control in smelting will add another 4 to 6 cents per pound to smelting costs in the future.[10]

Copper scrap substitutes for copper concentrates when the scrap contains significant impurities and requires smelting prior to refining. Often scrap copper, especially prompt industrial scrap, can be shipped directly to refiners, and may be viewed as a substitute for blister copper. If blister copper is worth 20 percent more than copper concentrates and the full 15 percent is taken as percent depletion, the price of blister copper would be depressed by approximately $(5/6) \times .48 \times .15 = 6\%$. At present, scrap copper competes with a virgin based product whose price may be lowered by at most 6 percent due to percent depletion.

In actual practice depletion is not always taken at the statutory 15 percent; the 50 percent of net income limitation, and cost depletion on certain properties reduce the actual rate of depletion. The Treasury Depletion Survey found actual depletion deductions in 1958, 1959, and 1960 were 11.7 percent, 12.8 percent, and 13.3 percent of gross income from copper concentrates.[11] Taking 13 percent as the average actual rate of percent depletion, the effect on price of blister copper is to reduce it by $(5/6) \times .48 \times .13 = 5.0\%$.

Corporation 10-K Reports provide the basis for an alternative estimate of actual depletion experienced, and also provide more current information. Because depletion is reported only as the percentage reduction in effective tax rates (see Chapter 3), the actual amount of depletion must be calculated indirectly.

Let r = Reduction in effective tax rate attributable to depletion
t = Rate of corporate taxation (.48)
G = Income before income taxes
D = Amount of depletion

Then: $r = t - t(G-D)/G$, and depletion may be computed as:
$D = G(r/t)$.

The actual depletion rate experienced is given by D/M, where M is the value of mineral concentrates produced. Unfortunately it is necessary to estimate the value of mineral concentrates through an indirect process, because their value is not reported in 10-K reports. A rather laborious and probably error filled calculation for Kennecott Copper indicated that depletion of $85 million was taken on mineral output worth some $740 million, for an estimated rate of depletion of 11.4 percent.

The impact of other taxes in mining is even more difficult to estimate. The previous discussion of expensing suggested that expensing of mineral exploration and development outlays in metal mining averaged about half of the deduction taken for depletion in excess of cost depletion. If it is assumed that recapture is postponed so far in the future that the present value of future tax liabilities is zero, the impact on market price would be about half that of depletion. Of course, if percent depletion were to be eliminated the mining firms would have some incentive to switch from expensing to cost depletion - thereby lessening the measured impact of expensing.

Earlier in this chapter the observation was made that the impacts of severance taxes are especially difficult to quantify. For those corporations itemizing all forms of taxation, severance taxes were about one-fifth of the depletion allowance.

The investment tax credit is one of the more significant tax subsidies available to industry, but because it is equally available to both primary and secondary producers, it would have an impact on relative prices in the two sectors only to the extent capital intensities differed.

The foreign tax credit and other special treatment of unremitted foreign income resulted in a reduction of 4 percent in the effective income tax rate for the Anaconda Company, but had no material impact on other domestic copper producers. Following nationalization of copper industry investments in Chile, the impact of the foreign tax credit upon the industry has been minimal.

2) Steel

The virgin raw materials used in steel production are iron ore, coal, and limestone. The intermediate product pig iron competes directly with scrap steel as the charge to the basic oxygen and open hearth furnaces. The basic oxygen furnace, which produces about 56 percent of domestic steel output, can accept charges of varying proportions, the upper limits on scrap now being over 40 percent if the scrap charge is preheated. The open hearth furnace, which is declining in importance and accounts for approximately 25 percent of domestic steel output, accepts a charge of both scrap and virgin product with no restrictions on input proportions. In electric furnaces pre-reduced iron ore is a technological substitute for scrap steel as an input, though relative input prices normally favor the use of scrap.

The principal tax preferences obtained by the producers of virgin inputs to pig iron production are depletion allowances on all three inputs, and capital gains which are allowed, but not widely utilized, on the production of iron and coal. The tax code permits depletion of 15 percent on iron ore, 10 percent on coal, and 14 percent on limestone. Prediction of the impact of tax preferences for the production of inputs to the steel making process will require knowledge of the stage of production at which the tax benefits may be taken. Depletion on coal is taken after mining and washing - essentially the final output stage. Percentage depletion on iron ore is taken at the concentration stage and on limestone it is taken at the crushing stage - both of which are also essentially final outputs.

The analysis of the impact of preferential taxation on primary extractive industries on material recycling must consider tax induced changes in relative prices at the point where scrap competes with the equivalent virgin input. In steel production the relevant virgin input is pig iron, but the calculation of the impact of taxation on its price is subject to unusually large margins of error. First of all the quoted market price of pig iron is unreliable since less than 10 percent of pig iron production is bought and sold on domestic markets. Pig iron production is dominated by a few firms and their reaction to changes in input prices is difficult to predict. Finally the technical possibilities for capital labor substitution in response to a change in relative factor prices are assumed (but not necessarily known) to be minimal.

Pig iron can be produced with some variation in inputs - especially in the amounts of coke and limestone which are used. According to Vaughan[12], the recent experience of the steel industry has been to use approximately 3,000 pounds of iron ore, 1,000 pounds of coke, and 400 pounds of limestone to produce a ton of pig iron. These proportions vary somewhat depending on the metal content of the iron ore, as well as on the coke and limestone proportion. The maximum impact of depletion allowances on the price of pig iron is obtained when all inputs are elastically supplied.

Table 6-4. DEPLETION ALLOWANCES IN PIG IRON COSTS

Input	Input per ton of pig (in tons)	Rate of Depletion	Input Price (May 1974) At stage where Depletion is taken	Net Savings in taxes
Metallurgical Coal	.77	10%	$30 per ton	$1.11
Limestone	.2	14%	$ 2 per ton	$ .03
Iron Ore	1.5	15%	$11 per ton	$1.19

Table 6-4 summarizes the maximum effect mineral depletion have on the price of pig iron. At a current market price of $77 per ton, the $2.33 attributable to depletion amounts to 3.0 percent of product price. The impact of percent depletion will be reduced to the extent cost depletion is used, to the extent the 50 percent of net income limitation applies, and to the extent supplies of the virgin materials are less than infinitely elastic. The combined effect of the separate limiting influences can be significant. For Pittston and Westmoreland Coal mineral depletion deductions ranged between 2.19 percent and 3.51 percent of final product price in 1973 and 1974, far less than the statutory 10 percent used in computations here.[13]

The Treasury Depletion Survey of 1958-1960 provides additional information on depletion rates actually realized. Table 6-5 reports depletion as a percent of gross income for the suppliers of primary inputs to pig iron production. Both cost depletion and the 50 percent of net income limitation act as constraints on depletion actually achieved.

Table 6-5. DEPLETION AS PERCENT OF GROSS INCOME

	Statutory rate	1958	1959	1960
Iron	15%	13.5%	13.4%	14.0%
Anthracite	10%	5.7%	3.6%	2.7%
Limestone	14%	12.4%	13.3%	13.2%

Source: President's 1963 Tax Message

State severance taxes may, to a considerable degree, counteract the favorable impacts of percent depletion on these extractive industries. The 15 1/2 percent Minnesota severance tax on iron ore and the 15 percent tax on taconites appear to more than offset the subsidy of percent depletion at 15 percent. (Recall that $d = s(t-1)/t$, so that for a tax rate of 48 percent a severance tax of 15 percent is exactly balanced by depletion at the rate of 16.25 percent.) Kentucky's coal severance tax of 4 percent approximately counters the depletion earned on coal (at least that mined in Kentucky).

Another special form of tax preference for coal and iron ore production is the capital gains provision on royalties. Section 631 of the Internal Revenue Code specifies that, for those producers using cost depletion to recover capital costs, the difference between the amount realized from the sale of any coal or iron ore from a property and the adjusted basis for that production is considered a capital gain, providing the property was held for at least six months prior to the production of the minerals. In actual practice, deductions for capital gains in iron and coal production are rarely taken (they amount to a savings in income taxes of about $5 million per year), primarily because most producers find percent depletion permits a greater deduction against tax liability than does cost depletion, even when the latter is coupled with a provision for capital gains.

3) Aluminum

Aluminum is manufactured by processing alumina (aluminum oxide) bearing ores such as bauxite to obtain alumina, and then electrolytically reducing alumina in a molten bath of cryolite into aluminum ingot. Percent depletion is allowed at a rate of 22 percent for domestic bauxite production and 14 percent for foreign production. Bauxite costs prior to the formation of the International Bauxite Association (IBA) in 1974 have been placed at about 10 percent of ingot costs.[14] Bauxite taxes in the amount of about 6 percent of ingot price were recently imposed by IBA and could, if allowed by the Internal Revenue Service, serve to increase the base on which depletion deductions may be taken by over 60 percent.

Domestic bauxite production accounts for about 10 percent of consumption, and the remainder is imported from various foreign sources. Although Jamaican bauxite deposits have approximately the same 50 percent alumina content as domestic sources, they enjoy significant advantages in terms of accessibility and silica content. Other important foreign bauxite sources are generally less competitive. Guyana's ore, though richer in alumina content at a 57 percent concentration, is covered with a heavy overburden, and Australian ore must be transported greater distances.

One significant area of competition between virgin and secondary aluminum supplies is as an input to the castings industry where scrap competes directly with primary aluminum ingot. Historically scrap, as secondary aluminum ingot, has been the dominant input, but proportions have varied depending on scrap availability and shipments by the castings industry. Another area of competition is between primary and secondary extrusion ingot which is shipped to independent fabricators. Because of input substitution at the ingot level, the impact of depletion deductions will be computed for primary aluminum ingot.

The maximum impact of percentage depletion on the price of aluminum ingot would be obtained if:

(1) Depletion is allowed on the value of bauxite including the foreign taxes (making bauxite 16 percent of ingot value).

(2) Primary ingot supply is infinitely elastic in the long run.

(3) Bauxite deposits are sufficiently profitable so that the 50 percent of net income limitation on depletion deductions does not apply.

On foreign sources of bauxite depletion could account for at most .16 X .14 = 2.2% of ingot price, whereas on domestic bauxite supplies depletion could account for somewhat more. Domestic bauxite prices and quantities used for the production of aluminum indicate bauxite could have accounted for 11 percent to 12 percent of ingot value in 1971. (Four tons of bauxite valued at $14 per ton were used to produce every ton of primary ingot worth $580 per ton.) Assuming bauxite now accounts for 18 percent of ingot value, depletion could amount to .22 X .18 = 4.0% of ingot value.

The actual experience in the aluminum industry in 1973 was as follows: Alcoa produced 1,625,000 tons worth $812.5 million and obtained percentage depletion of $11.6 million of 1.4 percent; Kaiser Aluminum and Chemical produced 847,261 tons worth $395 million and obtained percentage depletion of $7.5 million of 1.9 percent; and Reynolds Aluminum produced 464,368 tons worth $232.8 million and obtained percentage depletion of $5.3 million of 2.3 percent.[13, 15] Since Reynolds Aluminum controls most of the domestic production of bauxite, it is to be expected that depletion would be more important to Reynolds Aluminum as a percentage of final product price than it is for the other producers.

The impact of percent depletion in terms of lower prices for final outputs is, at most, equal to the tax savings, or 48 percent of the ratio of depletion to final product price. Percent depletion would thus reduce market price by somewhere between .7 and 1.9 percent.

4) Lead

The most common lead minerals include galena (lead sulfide), cerussite (lead carbonate), and angesite (lead sulfate).[16] Galena, the most abundant source of commercially mined lead, is often found mixed with traces of zinc, silver, and gold. Galena ores in Missouri, which are the source of over 70 percent of domestic production, are essentially free of trace metal contamination. Lead ores are normally milled at the mine site, and the lead is physically separated from other valuable ore constituents through differential flotation. Lead concentrates obtained from milling are then smelted in blast furnaces or open hearths to burn off the sulfur and reduce lead oxides to metallic lead. Lead bullion from smelters in Missouri is pure enough for most applications, but western and most foreign ores contain base metal impurities which must be removed through refining before the lead is sufficiently pure for many commercial uses. The gold content of western and foreign ores normally makes separate extraction of gold profitable.

Percentage depletion for primary production is allowed at the rate of 22 percent for domestic ores and 14 percent for foreign ores. Depletion is taken on the value of lead concentrates, a commodity which normally is not traded and for which representative prices are not published. The Internal Revenue Service uses a method called "proportionate profits" to allocate costs at various stages to the value of final output. For each producer apparent costs of mining, concentrating, smelting, and refining are computed and any residual profit is allocated among the various operations. Depletion is then taken on the estimated value added through processing to lead concentrates. The actual imputed value of lead concentrates for each producer will vary depending on the efficiency of the operation and the lead content of the ore being mined. The identical problem of imputing values to intermediate products which do not have readily defined market prices is encountered for other minerals such as copper.

Statistics on the value of lead concentrates were obtained indirectly from a recent Commerce Department publication.[17] In 1972 mine output of 900,000 tons of lead concentrates was valued at $137,300,000, indicating an average value of about 7.6 cents per pound. This compares with an average price of 15 cents per pound for refined lead for that year.

Lead recovered from scrap materials has exceeded domestic primary metal production since 1958 and is, therefore, of considerable importance in the domestic supply pattern. Secondary refined lead is indistinguishable from primary refined lead and substitution takes place freely. For most uses lead bullion from primary and secondary smelters also substitutes freely. Estimation of the impact of tax preferences on recycling will be based on a market model for metallic lead with a single demand curve and a supply curve composed of the summation of supplies from primary and secondary sources.

Computation of the actual tax savings derived from percentage depletion once again is complicated by the restriction that depletion not exceed 50 percent of net income from mining. Profit rates for the mining and concentrating facilities of major producers are unknown - here it is assumed profits are sufficiently large to permit the maximum possible deduction for mineral depletion. The primary lead supply curve would be shifted upward by at most .48 X .22 X 7.6/15 = 5.3% should the depletion allowance on lead be eliminated. Again the Treasury Depletion Survey enables one to compare realized depletion rates with the maximum permitted by law.[11] For lead and zinc (the two were grouped together) depletion as a percent of gross revenues from lead concentrates ranged from 9.5 percent to 11.4 percent, or far below the 23 percent permitted at that time. The primary reasons depletion deductions were so low is that the cost depletion method of recovering exploration and development outlays was more beneficial. Assuming the same pattern holds today, percent depletion may depress the price of primary lead from 2.5 percent to 3 percent.

5) Short Run Supply Curves

A significant portion of the estimated tax induced shift in final output price depends upon the existence of an elastic long run mineral supply curve. That supply may be less than elastic in the short run, due primarily to capacity constraints, undoubtedly holds for most if not all of the minerals discussed here. Though an apparently common phenomenon to mineral engineers, a backward bending short to medium run supply curve for mineral output is, to economists, an unexpected consequence of limitations in milling capacity.

Because cost of transporting mineral ores for processing would quickly absorb the entire value of mine output, ore concentration or beneficiation facilities, which mill and physically separate metallic constituents through differential flotation, are normally located at the mine site. Milling capacity at the mine effectively limits the rate at which ore can be processed in the short run.

Economists have demonstrated that, at least in theory, the present value of a mine is maximized by mining the highest grade ores initially and reserving lower grade ores for the future. Therefore an increase in the demand for final smelter or refining outputs resulting in higher metal prices should have no effect on the grade of ore presently mined. Indicative of the failure of the theoretical models to reflect actual mining decisions is this revealing quotation from Homestake Mining's 1973 annual report:

> "As the year progressed and the gold price rose, daily tonnage at the mine increased first by mining to a lower cutoff grade in all the active stopes and later by initiating production from blast hole stopes containing ore previously too low in grade to be profitably mined."

Extraction of low grade ores encountered in normal mining operations, which would be bypassed and perhaps irretrievably buried when metal prices are depressed, is profitable and extends the life of the mine when metal prices are high. Though a rigorous demonstration is difficult to formulate, mining of lower grade ores at certain locations during periods of elevated metal prices could well increase the present value of the mine.

The hypothesis that short to medium run supply curves are backward bending is further supported by actual production statistics for major western gold producers in recent years. For Homestake and Sigma production dropped significantly in 1973 despite a 68 percent increase in the average price during the year, while at Dome and Campbell Red Lake output was approximately unchanged. The average grade of ore mined by Homestake fell from .285 oz. per ton in 1971 to .278 oz. in 1972 and .227 oz. in 1973. For the other three producers the average grade mined also declined as the price of gold advanced.

Table 6-6. GOLD PRODUCTION AND MILLING STATISTICS

	1973	1972	1971
Average Price Received	$95	$56.50	$43
Homestake Mining	357,634 oz 1,575,000 tons	407,462 oz 1,466,000 tons	513,374 oz 1,801,000 tons
Dome Mines Ltd.	148,500 oz 682,000 tons	146,000 oz 630,000 tons	
Campbell Red Lake	196,000 oz 304,000 tons	197,000 oz 303,000 tons	
Sigma Mines	78,000 oz 521,000 tons	86,000 oz 521,000 tons	

Source: Corporation 10-K Reports

Should short to medium run primary metal supply curves be backward bending the assumed connection between elimination of the mineral depletion allowance (or other tax subsidies) and higher virgin metal prices would have to be reexamined. Without the depletion allowance the short run response of mining firms should be to increase the cutoff grade below which ore will not be removed. Given a desire to maximize the present value of the mine, the mine owners could well continue mining at a rate which would fully utilize existing milling capacity as long as receipts covered variable costs. Although ore removals and quantities milled might remain constant, the output of metal would rise as higher grade ores were mined. All of this indicates that the short run response to the elimination of the mineral depletion allowance, could, depending upon the mineral and opportunities to upgrade the grade of ore being mined, result in an increase in virgin metal supplies and a concomitant decrease in metal prices.

CHAPTER 6

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CHAPTER 7

MATERIALS FLOWS AND THE SPECIFICATION OF ECONOMETRIC MODELS

The purpose of this chapter is to provide more information about technological and organizational aspects of the industries which process and consume secondary materials. The plan of the chapter is as follows. Section 1 is devoted to defining terms and describing the categories commonly used in the scrap industry for classifying secondary materials. Section 2 presents a schematic description of primary and secondary materials flows. The emphasis in this section is on identifying the points at which substitution of secondary for primary materials occurs. Section 3 describes in somewhat greater detail the secondary materials flow. In particular, those factors which are relevant to the task of formulating an econometric model of supply and demand are discussed. In section 4 statistical problems associated with estimating long-run supply and demand responses are reviewed with special attention to problems peculiar to modeling secondary materials industries.

I. BACKGROUND

A. Home Scrap

Home scrap is the name given to secondary materials which are generated in production processes and then re-used at the same location, usually in the same production process. Refining and smelting processes which produce copper, aluminum, lead and steel in a first, relatively pure metallic state generate home scrap. Ready accessibility, cleanliness, and known chemical composition make this material valuable to primary metal producers so that there has never been any problem with home scrap going unused or doing damage to the environment. Nor is it likely that changes in metallurgical technology will alter this situation.

Because home scrap is not traded in the marketplace, it is not appropriate to speak of a supply curve for home scrap. There is no price established to which firms respond in deciding how much of their own by-products to recover.

It is conceivable, nonetheless, that the amount of home scrap which gets recycled within a plant mill is dependent upon the price of virgin inputs. If the price of virgin ore were relatively low, primary producers might allow some portion of home scrap which was less easily recovered to go to waste. As the price of virgin ore rose these producers might find it in their interest to spend more on housekeeping functions so as to increase recovery of home scrap and thereby reduce their requirements for purchased virgin inputs and/or the rate at which they used up their own stocks of virgin raw materials. In effect, there is a substitution of labor and perhaps capital for raw materials in response to an increase in the price of raw materials. Theoretically then there might be some relationship between the quantity of home scrap recovered and the price of virgin inputs. It is our impression, however, that this relationship is not a significant one, and therefore is not worth investigating too closely. Available studies seem to concur that primary metal producers presently recover virtually all of their own waste products and would continue to find this an economically efficient practice even with sharply declining prices for virgin inputs.

As long as all home scrap that is physically available is getting recovered, its consumption rate should vary in direct proportion to output of primary metal. This proportion is simply equal to the rate at which by-products are generated in a plant. This proportion may itself be changing over time as newer, more efficient techniques increase production yields. For instance, in the steel industry while traditional ingot practices involve metal losses of 25 percent to 30 percent, continuous casting which eliminates the need for this production stage involves a loss of only five to 10 percent. In the future, if continuous casting becomes more widespread there might be a significant reduction in the generation of home scrap. On the other hand, over the last twenty years there has been an increase in the generation of home scrap caused by a shift in demand toward higher quality steels for which production yields are lower.

These examples point to the need to interpret statistics on home scrap with some care. A reduction in home scrap consumption which is brought about by an innovation such as continuous casting does not result from any lessening of recycling efforts. There are no harmful environmental consequences which accompany such a change since there are still no ferrous residuals flowing into the environment from this sector. Home scrap is still fully recovered. Nor is such a change accompanied by any increase in the rate at which virgin sources of iron are depleted.

It is also improper to infer that such a decrease in quantity of home scrap consumed necessarily makes room for increased opportunities for the consumption of scrap from other sources. For example, while steel furnace inputs (aggregated over all production processes) have traditionally consisted of about 50 percent scrap by weight, this number is not rigidly determined by any technological factors. It is improper to assume that as home scrap consumption varies, compensating changes in the consumption of scrap from other sources leave this 50 percent figure unchanged. A closer look at the various technological factors affecting the demand for scrap in different steel-making processes is necessary in order to determine the relation between home scrap consumption and the demand for other scrap inputs

Finally, there is the more basic problem of whether it is appropriate to combine home scrap together with scrap from other sources so as to obtain a figure defined as the recycling rate. As long as changes in home scrap consumption rates are merely indicative of changes in the path that raw materials follow within a plant, inclusion of home scrap in recycling rates seems somewhat artificial. This is especially so where these internal process changes do not alter the flows of raw materials into or products and residuals out of the plant. The calculation of a recycling rate which includes home scrap can be misleading since many persons would interpret the recycling rate as a measure of the amount of discarded material diverted from the environment back into the production stream. Inclusion of home scrap which never leaves the mill and which would be re-used under any plausible set of economic and technological conditions, overstates recycling thus interpreted.

B. Prompt Scrap

This category includes materials which originate as by-products of one production process and are then shipped off to other plants to be used as inputs to other production processes. Typically prompt scrap is generated in fabricating processes in which intermediate metal or paper products are fashioned into final products. It is then re-used in processes which precede the fabrication stage, perhaps to produce the same intermediate goods from which it originally came. For example, the production of automobile fenders involves cutting flat rolled sheets of steel into irregular shapes. The trimmings from this operation become prompt scrap, which is returned to steel mills and used as an input in the production of more raw steel.

Prompt is sometimes shipped directly from fabricating plants back to user mills. This is common practice among fabricators who have relatively large quantities of metal or paper to dispose of, especially where the preparation of this material for sale to a mill requires minimal efforts at sorting and processing. Smaller fabricators and those whose by-products require more processing generally sell to scrap dealers who then undertake the necessary preparation and sell scrap to user mills.

While it is thought that, like home scrap, most physically available prompt scrap makes its way back into the production stream, considerably more uncertainty surrounds the estimates of prompt scrap recovery ratios. Several factors make it difficult to know exactly what proportion of available prompt scrap is being recycled; information is lacking both as to the quantity of prompt which is generated and the quantity which re-enters the production process. First, locational considerations make the analysis of this sector a more complicated undertaking than the analysis of the home sector. In the case of home scrap it was possible to determine that all or nearly all available scrap was recycled by observing that existing technology made it feasible for mills, no matter where situated, to recover and consume their own scrap. However, the recycling of scrap from prompt sources involves more than in-plant housekeeping efforts directed at the recovery of relatively uncontaminated by-products. Prompt originates in dispersed locations, most of which are physically separated from the mills to which recycled material must ultimately return. Transportation costs will vary among different sources and may be a significant part of the total cost of recycling, particularly for those sources which are most remote from mills. This makes it hard to generalize about the costs of recycling prompt scrap from observations on the behavior and the technology of a few fabricating firms. It is often argued that more remote sources of scrap increase their recovery efforts as scrap prices rise precisely because this enables them to bear higher transportation charges.

A second factor which complicates analysis of the prompt scrap sector is that prompt is generated as a by-product in a large number of different production processes. Again this situation is in sharp contrast to that prevailing in the home sector. There are only a handful of processes that need to be examined in order to establish the rate at which home scrap is generated and the ease with which it can be recovered.

Determination of the rate at which prompt scrap is generated requires detailed information on the many different production processes that transform raw steel, copper, aluminum, lead, and paper into a wide variety of intermediate and final products.

A third reason that it is difficult to specify the recycling rate for prompt scrap is that even the present consumption rate of prompt scrap cannot be reckoned with any accuracy. The dealers who handle prompt scrap also handle scrap derived from obsolete consumer products and industrial equipment. Often no statistics are kept which give the quantity of material flowing into dealers' yards, broken down according to source. Consequently, prompt scrap is often lumped together with obsolete under the heading "purchased scrap" and it is impossible to know how much of this is prompt and how much is obsolete.

Both as a definitional matter and as a matter of public policy it is not clear whether the recovery of prompt scrap should be regarded as a "recycling" activity which it might be appropriate to encourage through some sort of government action, or regarded rather as an internal production flow. In contrast with home scrap the flow of prompt scrap extends physically beyond the boundaries of the mill. Some prompt scrap is not recovered and this may impose social costs either in the form of disposal costs not fully borne by the firm which generates the scrap, or where proper disposal is not undertaken, in the form of costs associated with a littered landscape. Also, the failure to recover prompt scrap causes the depletion of resources to proceed more rapidly. These factors suggest that recovery of prompt scrap is properly regarded as a recycling activity. On the other hand much prompt scrap is easily recoverable and therefore so valuable that like home scrap it is automatically recovered without regard to conditions in the scrap market.

C. Obsolete Scrap

This category includes all materials contained in industrial equipment and in consumer goods which are no longer in use. It is also referred to as old scrap (as distinguished from new scrap which consists of home and prompt).

The definitional problems which were encountered with home scrap and prompt scrap do not arise in the case of obsolete scrap. Clearly the recovery of this material constitutes "recycling" in the sense in which this term is ordinarily understood.

The category "obsolete scrap" comprises a considerably more heterogeneous mix of materials than either home or prompt scrap. In a modern industrial society metals and paper are contained in a vast array of different final products. This diversity is reflected in the materials flow of obsolete scrap.

The costs of recovering a particular material from a particular final product are determined by factors such as product design, salvage value of other components or materials in the same product, disposal practices, and the geographical location of the product when it becomes obsolete.

D. Scrap Grades

In addition to the categories discussed above, in which scrap is classified according to its source, there exist a number of scrap grades for each of the materials of interest to us. Classification into one of several grades comes after scrap materials have received some initial processing such as sorting, separation from the obsolete products which contained them, cleaning, and assembly into easily transportable units. Typically classification according to grade occurs at the point where scrap is sold by scrap wholesalers to user mills such as secondary smelters.

The quality of scrap materials is often closely related to their source (home, prompt, or obsolete), so that particular grades may contain materials which come exclusively from one source. In some cases the specifications for a grade may explicitly exclude materials from one source or another. However, since grade classifications reflect the quality achieved after some processing has occurred it is not unusual to find that a single grade contains materials from more than one source.

E. Organization and Operations of Scrap Industries

Scrap materials are collected and processed by numerous self-employed individuals and small firms. The industry is characterized as competitive. Firms enter and exit the industry quite rapidly in response to changes in scrap prices. Historically capital requirements have been low, though the advent of such mechanical devices as the shredder for scrap steel have increased the costs of entry substantially in some segments of the scrap industry. The scrap industry typically is characterized as labor intensive. Labor, transportation and raw material acquisition costs are the largest components of cost to the industry. Although little has been written on inventory holding behavior of scrap processors, inventory accumulation and depletion in response to anticipated future prices for scrap appears to be an important facet of the scrap metal industries. In the wastepaper industry, physical deterioration of the product over time and the high cost of storage space in relation to product value both limit the desirability of holding large inventories.

Much of the prompt industrial scrap and some of the obsolete scrap is obtained under contract with scrap generators. Although other, marginal sources of supply are available and exploited when prices are high, the existence of these contracts limits the ability of the scrap industry to contract when demand for the outputs of the scrap industry is low.

Following collection, scrap materials are processed in two basic operations: (i) identification and segregation, and (ii) physical preparation. Identification is most commonly made by visual and mechanical measurements of such parameters as color, hardness, attraction to magnets, and spark testing. Although precise identification is required infrequently, it can be made by chemical and spectrographic analysis. The degree of segregation required varies with the source of the scrap as well as the needs of scrap consumers. After identification and segregation, contaminating materials are removed and the scrap is packaged into bundles of a standard size for efficient use by consumers.

II. MATERIALS FLOWS

In this section we present a general schematic representation of materials flows in the economy. Our aims are twofold. First we wish to convey to the reader some feeling for the wide range of points in the production cycle at which substitution of secondary for virgin materials can occur. Second we wish to give a summary account of the points at which substitution actually does occur for each of the five materials considered in this report.

In some respects the distinction between a group of production processes which supply secondary materials and a group of production processes which demand secondary materials is an artificial one. The movement of secondary materials through the economic system can be better understood as a flow consisting of a series of production processes in which the discarded by-products of production and consumption activities are transformed into final consumer goods or capital goods. All of the intermediate production processes in this flow are involved in both consuming or demanding secondary materials as inputs, as well as in producing or supplying secondary outputs.

All production processes can be placed into one of six broadly defined categories. Three of these categories constitute what we refer to as a secondary materials sector. Production processes in this sector are those which transform secondary material inputs into intermediate and final products. These are production processes in which all or almost all of the important material inputs are from secondary sources. While distinctions which are based on terms such as "almost all" and "important material inputs" may seem a bit vague, they are sufficiently precise for our purposes. The other three categories make up the primary materials sector. This sector includes all other production processes, both those which use only virgin material inputs and those which handle some mix of virgin and secondary materials.

Starting with the secondary sector, the first category is labeled Secondary Materials Collection. This category includes those activities generally undertaken by scrap dealers or scrap processors such as collection, dismantling of obsolete products, sorting, cleaning, and the breaking of large pieces of scrap or the consolidation of small pieces into forms which are more convenient for handling purposes. In general these are activities which alter only the physical characteristics of secondary materials.

Following this comes a category which is denoted Secondary Materials Processing. Activities in this category represent a continuation of those in the preceding category insofar as the object is still to reduce a diverse collection of material inputs in somewhat contaminated form, to a relatively small number of outputs of purer and more uniform quality.

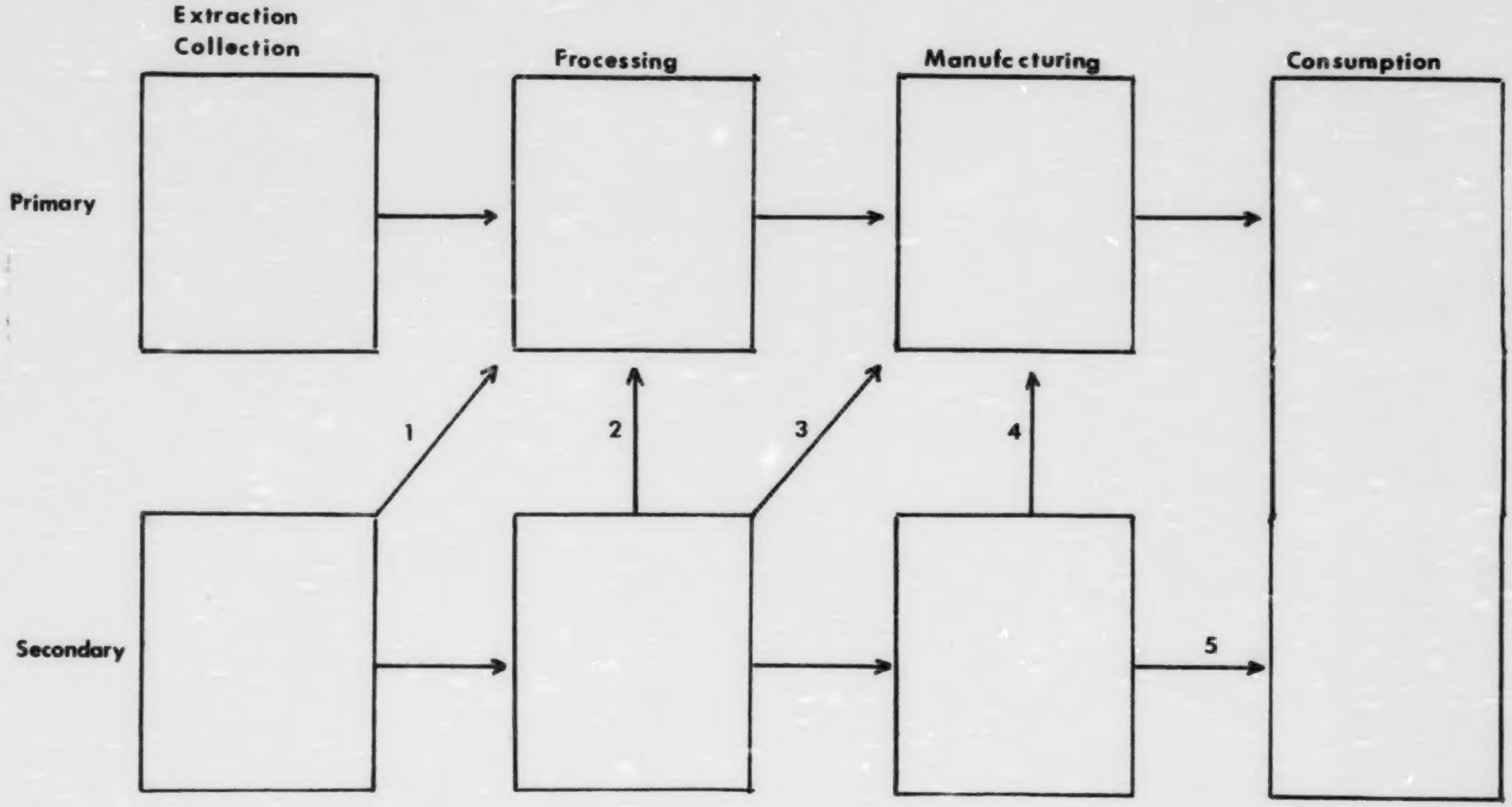
These first two categories are distinguished from one another by the fact that activities in the latter group are substantially more complex involving chemical as well as physical alteration of the material inputs. Typical processes in this category are the operations of secondary smelters of non-ferrous metals. These facilities consume processed scrap which they have purchased from dealers or sorted and processed themselves. Inputs are melted down, various contaminants are driven off, and an output of secondary metal ingot is obtained.

Following Secondary Materials Processing comes Secondary Manufacturing. Manufacturing operations are defined as those processes in which raw materials which have been refined into a relatively pure form are shaped or combined with one another into a variety of intermediate goods and ultimately into final products. This category is very much smaller than the two preceding ones since most secondary materials get combined with some primary materials at the manufacturing level and are thus reabsorbed into the primary sector. Very few final products are manufactured from 100 percent recycled materials so that the secondary materials flow is rather insignificant as it enters the consumption sector.

The activities in the primary materials sector can be divided into three categories which parallel those in the secondary sector. Analogous to scrap collection activities are operations such as mineral extraction and timber cutting in which virgin materials are severed from their natural environments. As with secondary materials, it is convenient to include in this category those initial stages of physical processing such as screening or concentration of ores which are undertaken at the same site. Following this come Primary Materials Processing. These operations are often somewhat more complex and more capital and energy intensive than counterpart secondary processing operations. This is so with most metals, where primary processing may require the separation

FIGURE 7 - 1

MATERIALS FLOWS


Extraction
Collection
Processing
Manufacturing
Consumption
Primary
Secondary
1
2
3
4
5

of metal from ores that are relatively low in metal content, while secondary processing involves refining away minor impurities from metals which have already been separated from their ores. Primary Manufacturing includes all manufacturing processes except those few in which all or nearly all materials inputs come from secondary sources.

The numbered pathways indicated on the diagram show the points at which secondary materials substitute for virgin materials and virgin based products.

Scrap materials which need only be collected, and perhaps physically altered, to become suitable as inputs to primary production processes move along pathway #1. Generally this material is of high quality to start with, most likely originating as home or prompt scrap. It must be clean and its chemical composition must be known with a great degree of certainty. An example of a secondary material which follows this path is that portion of scrap copper which is consumed in primary smelting and refining operations along with ores, concentrates or primary blister copper. Another example is that portion of iron and steel scrap which is consumed in basic oxygen furnaces and open hearth furnaces along with pig iron to produce carbon steel.

Some scrap materials become acceptable as inputs to primary materials processing operations only after they have received somewhat more extensive treatment. These materials go from scrap dealers to secondary processors and then along pathway #2 to the primary sector. An example is waste paper which is de-inked and re-pulped before being used as an input which substitutes for virgin pulp in the production of tissue.

Much of the scrap which enters secondary materials processing facilities is converted into intermediate products that compete directly with virgin based products at the manufacturing stage. This situation is represented as pathway #3 in the diagram. Some amount of all the materials we are considering re-enter the primary materials flow in this way. Lead from secondary smelters and refiners is indistinguishable from primary lead. Both products enter as inputs to the same manufacturing processes. Some scrap copper is smelted and refined into secondary grades that are identical to grades of primary copper.

The case of steel is slightly different. Electric furnaces which consume only scrap are essentially secondary materials processing operations, despite the fact they are sometimes run by the same firms which operate furnaces that consume mostly virgin inputs. Unlike copper and lead, where primary and secondary refined metals are virtually identical, the output of electric furnaces is generally limited to high alloy grades of steel, so that competition between primary and secondary products is confined to only part of the market for raw steel.

Pathway #4 represents the situation where scrap is processed into secondary raw materials which remain in the secondary sector through the initial stages of manufacturing. Intermediate goods from the secondary manufacturing sector are then combined with other intermediate goods from the primary manufacturing sector to form final products.

The examples we have in mind here are the aluminum, iron, steel, brass, and bronze foundry industries. These are characterized as secondary manufacturing industries because all or nearly all material inputs are produced from scrap. Most of the outputs of these industries are intermediate goods, such as engine blocks, which are used as components in a wide variety of final products. Some foundry products are themselves final goods and are therefore properly classified as following pathway #5.

Pathway #5 represents the situation where scrap inputs are processed and manufactured into final products made up entirely of secondary materials. The best known example of a product which fits into this category is paper which is made from 100 secondary fibers.

III. FACTORS AFFECTING MATERIALS FLOWS

In order to understand how changes in technology and/or public policy are likely to affect the rate of secondary materials throughput, one needs something more than just a general description of the entire materials transformation process. A somewhat narrower focus is called for which gives detailed information about factors affecting the rate of flow of secondary materials at specific points in the flow process. In this regard economic concepts of supply and demand can be brought into play. It is often useful to choose a particular point in the materials flow at which the preceding production activities are viewed as supplying secondary materials and the production and consumption activities which follow are viewed as creating demand for secondary materials. One then attempts to identify parameters which affect the rate at which producers are willing to supply secondary materials, and parameters which affect the rate at which other producers or final consumers wish to consume secondary materials. Taken together these two sets of factors should determine the flow rate which actually prevails at this point. If in addition one is able to relate changes in public policy or technology to changes in the values of one or more of the parameters influencing supply and demand it is then possible to predict the effect upon the recycling rate of specific changes in technology or public policy.

The question which immediately arises is what are the important points in the flow to which our attention should be directed. Most discussions of recycling treat as supply activities those engaged in by scrap dealers and those engaged in by individuals or firms that prepare or upgrade the secondary materials which they themselves generate. These activities include such things as collecting scrap from the environment, cleaning it, and sorting it. In general they can be characterized as activities which alter the physical properties or alter the location of scrap materials. All production and consumption activities which come later in the materials flow are placed on the demand side.

In some respects this is an appealing way to separate supply from demand. It focuses on the first point where it is possible to measure the flow of secondary materials using standard economic concepts. Prior to this point the secondary flow is comprised of a heterogeneous mix of materials which vary widely with respect to location, physical quality, and chemical characteristics. Prices or values can be assigned to such scrap materials only on a highly specific basis which takes account of the distinctive physical, chemical, and locational attributes of particular quantities of scrap.

Once scrap has been processed by dealers, however, the flow of secondary materials can be neatly broken down into a manageable number of homogeneous product classifications conforming to the scrap grades traded in the market. Prices exist for specific grades and price indexes can be constructed for categories which represent the aggregation of several grades.

While a supply equation for secondary materials at the stage where they have been collected, sorted, and cleaned is useful for some purposes, it may be that this is not the most appropriate point in the secondary materials flow to analyze supply and demand. To some extent the choice of a point at which to measure supply and demand is dictated by what is being studied. For purposes of this study the rate of secondary throughput relative to virgin throughput is of interest so that it is important to look with some care at those points in the flow where there is actual or potential substitution between virgin and secondary materials.

Unfortunately it is difficult to generalize about all of the consumption and production processes in which primary and secondary materials substitute for one another. The stage at which actual or potential competition occurs, differs among various materials. For instance, a considerable amount of scrap iron and steel goes directly from the scrap dealer into steel furnaces that simultaneously consume both scrap and virgin iron bearing inputs to produce raw steel ingot. Old scrap aluminum, on the other hand, goes to secondary smelters where it is made into secondary ingot, a product which substitutes at a later production stage for primary ingot made from virgin aluminum.

Even for a single secondary material one observes substitution occurring at a number of points. In the case of copper, some scrap which has only been sorted and cleaned is used as an input at primary copper smelters. In this use it substitutes for virgin copper bearing materials at a relatively early stage in the production of refined copper. Other copper scrap is upgraded further at secondary smelters and secondary refiners. These firms transform raw scrap copper into either secondary refined copper, which is identical to refined copper produced at primary plants, or into alloy ingot which substitutes for refined copper in some uses.

Besides technical possibilities for substitution which constrain opportunities for augmenting the flow of recycled materials, a host of other factors affects the rate at which scrap is collected and processed. The remainder of this section is devoted to a discussion of two of the more important recycling parameters which can be incorporated in econometric models of the scrap industry. These factors are scrap availability and the point in the materials flow at which to specify the model. Specification of other important variables, such as price, industrial activity in various sectors, and primary material production, is considerably less difficult and is left to the separate analyses of scrap industries which follow this chapter.

A. Availability

It is useful to think of the materials which have become available for recycling as a resource base for the scrap industry. The level of effort expended in exploiting this resource base is determined by the prices offered for processed scrap. The actual quantity of scrap which is recovered through these efforts depends upon prices. If the resource base were stable over time there would be no reason to explicitly include it in our analysis. However, it does change over time and for this reason econometric models of the supply of scrap materials must include some index which represents those changing aspects of the resource base which affect the costs of scrap recovery.

In order to design an index which measures the size and quality of the resource base it is useful to look first at the forces which cause it to change over time. Basically there are three such forces: flows in, deterioration, and flows out. Scrap materials enter the stock as final products wear out and as industrial by-products are generated. Materials which have entered the stock may deteriorate or become less accessible as they remain there for some time. And finally materials are removed from the stock at such time as their recovery becomes economically profitable.

Materials become available for recycling as final products wear out and are retired from service and as residues are generated in industrial processes. The flow of worn-out final products depends upon the quantity of final products produced in earlier periods and the rate at which they decay. Although the production of different final products normally is recorded quite accurately, a large variance in the rate of decay among products and also within any single product category limits the reliability of final goods production statistics from prior periods as a measure of the current flow of obsolete materials into the resource base of the scrap industry. An important exception to this general rule occurs when the time-in-use for a product is short and/or has a relatively small variance. Replacement storage batteries provide an example of this phenomenon, since most batteries lose their ability to hold an adequate charge after a period of service of from 24 to 36 months. Newsprint is another example where time-in-use is quite short and recent production statistics provide a good measure of current generation of obsolete scrap.

Nearly all prompt industrial scrap is recycled regardless of the price of scrap. This is a reflection of the fact that prompt scrap is normally collected under contract and once collected its sale at any positive price is preferable to paying for its disposal at a municipal dump. The primary determinants of the flow of prompt scrap are current or nearly current indexes of industrial activity in product fabricating and manufacturing operations.

Once materials are available for recycling they begin to deteriorate and continue to do so until they are collected by scrap dealers. Hence, the longer the lags between the generation of materials available for recycling and the collection and processing of these goods, the less of each good that is available for recycling.

The third and final way in which the resource base may change over time is through the removal of materials which are recycled. This flow of materials out of the scrap reservoir is particularly important for purposes of measuring the availability of scrap. The assumption that scrap dealers behave rationally guarantees that the most accessible materials are always removed first. Therefore, depletion of the resource base not only diminishes the overall quantity of scrap, it also lowers the quality of the resource base so as to raise the cost of obtaining scrap at the margin.

If there were no materials entering the resource base then the marginal costs of obtaining raw scrap would rise with each successive unit of scrap removed. It would then be appropriate to include cumulative removals of scrap from the reservoir as an independent variable in the supply equation.

Since the scrap reservoir is constantly being replenished, however, such a model would not be correctly specified. One possible situation is that flows into and flows out of the reservoir achieve a balance such that a quantity q_o can be supplied each month without causing any shift in the marginal cost curve. If there were a temporary increase in scrap demand so that for some months quantity q_1 (greater than q_o) was supplied, all other flows remaining constant, then the initial equilibrium would be disturbed. The resource base would be depleted for some number of succeeding months during which the marginal cost curve would shift upwards.

Once demand settled down to its normal level, flows of scrap into the reservoir would build it up again, thereby restoring the equilibrium marginal cost conditions.

This scenario suggests that it is removals of scrap during recently preceding months rather than cumulative removals which are related to the marginal costs of obtaining scrap. The most direct way of capturing this relationship would be to use a lag structure on the dependent variable as a proxy for the availability of scrap. This treatment would take account of materials flows out of the reservoir and would account in a rather crude way for flows of scrap into the reservoir. However, variations in the flow of scrap into the reservoir would not be handled very adequately. For instance, it might happen that during a period in which an unusually large amount of scrap was supplied (quantity q_1), there was also an unusually high rate of flow of raw scrap materials into the reservoir. In this case a proxy based on lagged quantity might indicate a significant deterioration in the reservoir even though materials flows into the reservoir left it unchanged.

In order to minimize the chance of this sort of error lagged scrap prices can be used in place of lagged quantities. The idea here is that past prices give an indication of how difficult it was to obtain marginal units of scrap in preceding periods. If prices were high, then scrap retrieval efforts must have been carried to the point where the last units of scrap to be recovered were fairly inaccessible. Thereby the reservoir must have been left relatively depleted. Conversely, if prices were unusually low, then even scrap which was reasonably accessible would have been left and raw scrap would remain relatively abundant. For both of these hypothetical cases, the lagged quantity of scrap supplied might have been high, average, or low, depending upon the rate at which raw scrap entered the reservoir during these months.

Obviously lagged prices are still not the perfect proxy. Extremely sudden changes in the rate at which scrap flows into the reservoir could lead to a situation in which this proxy gives a distorted picture of scrap availability. Imagine a situation in which a large fleet of aircraft is rendered available for recycling through retirement of the planes. Even if the price of aluminum had been high in prior periods and collection of relatively inaccessible materials had taken place, there may be an abundance of scrap aluminum in the present period. While not a perfect proxy it is felt that past prices give the best practical measure of the extent to which the reservoir has been depleted.

B. Model Specification

The stage at which to establish an econometric model of an activity which involves several stages of processing is quite arbitrary. At any point in a materials flow a line of demarcation may be interposed with the flow preceding the line termed supply and the flow beyond the line termed demand. In many cases the processing stage at which the model should be constructed is obvious once the desired outputs of the model are stated. For example, if one desires information on the impact of demand shifts for final outputs on market prices, one would estimate demand and supply equations for final outputs. In other situations the absence of reliable data precludes the estimation of market relationships. This report is concerned with the manner in which taxation in the virgin material sector affects flows through the secondary materials sector. Accurate estimation of these effects is rendered difficult because we are studying a second-order phenomenon and because the long-run impact is likely to be quite different from the short-run responses that are observed as market prices fluctuate.

Inasmuch as we must estimate second order effects to determine the impact of primary material taxation on secondary material use, the econometric specification must establish a link between virgin and scrap material use. There are two basic alternatives for connecting the two sectors. The first is to identify existing points of substitution and estimate market relationships at these points. For example, scrap steel and pig iron freely substitute in some steel making processes. Thus an econometric model of the steel making industry would be useful in measuring substitution and competition between scrap steel and virgin based materials. The second alternative is to assume long-run substitutability at some point as materials flow through the processing, fabricating, and consumption sequence. For example, although scrap lead and virgin lead concentrates are processed separately to yield sets of final outputs which differ considerably in composition, final outputs of the two sectors are virtually indistinguishable and should substitute freely in almost all end uses. Thus an econometric model of the lead industry which specified a single demand equation for all final lead outputs and separate supply equations for the virgin and scrap sectors would be adequate for our purposes.

A second critical aspect of model specification concerns the type of data to be used. Within the constraints of data availability we normally had the option between annual and monthly data. Annual data would be most reliable and appropriate for the estimation of the long-run price elasticities of demand and supply of interest in this study. Two factors limited our use of annual model specifications. First was the problem of identification of the separate equations in each model, given that virtually the same set of variables appears in both supply and demand evaluations in many instances. The second factor was data consistency. Many of the crucial data series have been kept on a consistent basis for relatively short periods of time. Periodically the method of computing a statistic is abruptly revised and often no formula is provided for the integration of the separate series into a consistent whole. Often we were lucky to find ten consecutive years of data which had been computed by the same method. In a time series equation with two or three independent variables, ten observations are far too few with which to make accurate parameter estimates.

Identification problems deserve further comment. When identical variables affect both supply and demand, a regression of equilibrium quantities on this set of variables may produce significant coefficients, but it may be impossible to determine if one has a demand equation, a supply equation, or a combination of the two. For example, two variables, price and current industrial activity in product fabricating, may be the principal determinants of demand for the output of a scrap industry.

The supply of obsolete scrap is likely to be affected mainly by the price of scrap, and the supply of prompt industrial scrap is most strongly affected by recent activity in some of the same fabricating sectors which are a source of demand. The lag between fabricating activity being a source of demand and a source of supply is normally a few months at most. Therefore, annual data for both supply and demand equations would be identical, or nearly identical, even if one could make the two of three month adjustment in the fabricating series for the supply equation. On the other hand, the specification of a monthly model permits the use of distinctly different data sets for demand and supply.

In the separate industry analysis which follow in chapters 8 through 12 we used the following specifications.

Table 7-1. INDUSTRY SPECIFICATION

Industry	Stage Where Substitution Is Modeled	Observation Interval
Steel	Inputs to Steel Production	Monthly
Paper	Inputs to the Production of Tissue, Newsprint, Paperboard, and Corrugated Medium	Monthly
Copper (a)	Inputs to Production of Refined Copper	Monthly
Copper (b)	Final Outputs	Annual
Lead	Final Outputs	Annual
Aluminum	Inputs to Non-integrated Mills	Monthly

IV. LONG-RUN PARAMETER ESTIMATION

For purposes of this report we are most interested in the long-run supply elasticities for scrap materials. This is because we wish to predict how much the rate at which scrap is supplied will rise following first, a lasting increase in its price, and then, a period of time sufficiently long for all adjustments to the new price to be worked out. Therefore, two questions should be addressed right at this point: 1) Does the analysis of monthly data produce long-run parameter estimates, and 2) assuming it does not, what relationship is there between our estimated elasticities and the true long-run elasticities?

The answer to the first question is that estimated annual equations are far more likely to yield long-run parameters than would similar equations estimated with monthly data. In order to estimate directly a long-run supply equation one would have to observe changes in the quantity of scrap supplied which accompanied relatively long-lived changes in the price level of scrap. Monthly equations which are developed for scrap paper, steel, copper and aluminum are based upon responses of scrap dealers to monthly variations in the price of scrap.

The answer to the second question is not so straightforward. There are a number of reasons why one might expect the elasticities we have estimated based on monthly data to differ from the long-run elasticities. Unfortunately, it is the case that some of these reasons suggest that our estimated elasticity is lower than the long-run elasticity while others suggest just the opposite.

To begin with we examine the standard economic distinction between the short-run and the long-run. The short-run is defined as a period of time in which at least one factor of production is fixed. In the long-run all factors can be varied.

Assume that all firms in an industry are initially in a long-run equilibrium position. Every firm consumes all inputs and produces output at rates which minimize its average total costs; output price is p_0 and firms produce at an aggregate output rate of q_0. It is generally accepted that the short-run supply response to an increase in output price from p_0 to p_1 will be less pronounced than the long-run response.

Over a period of, say, a few months, a firm may increase its output by hiring more labor or operating with extra shifts. However, it must make do with its existing physical plant. As the firm strains to produce at a rate which is beyond what its plant and machinery were designed for, marginal production costs may begin to rise very rapidly. Finally, there may be an absolute constraint upon the rate at which outputs can be produced.

Over a longer period of time a firm has the opportunity to expand its physical plant. It no longer must operate plant and machinery at a rate which is technologically inefficient in order to produce a large quantity of output. Once new capital stock is in place, the short-run marginal cost curve shifts outwards, so that the output can be expanded further before reaching the point where the marginal costs of producing additional output exceed the output price.

Applied to our analysis of the scrap industry, this line of argument would lead us to expect the long-run supply elasticity to be greater than our estimated elasticity which is based on monthly data. Scrap dealers may have limited yard space, shredder capacity and baler capacity which cannot be expanded within a single month, but which can be expanded over the course of a year of two. Also over a longer period of time, it is possible for facilities to be opened in fringe areas where the relatively low volume of scrap generated is only sufficient to make scrap recovery a profitable venture when scrap prices are high.

A second reason why one might expect the long-run supply elasticity to differ from estimated elasticity goes back to the notion that one of the inputs to the scrap production process, namely raw scrap, is drawn from a depletable resource base. Again, assume that the scrap industry is initially in equilibrium supplying quantity q_o at price p_o and that an increase in demand drives the price up to p_1. We know that cost minimization by scrap dealers implies that the most accessible scrap inputs are collected first. At the higher price p_1 scrap dealers are able to increase the quantity supplied to q_1 by extending their collection efforts to less accessible sources of raw scrap.

It may be the case that a price increase which lasted for only one month would be accompanied by a relatively large increase in the quantity of scrap supplied as accumulations of scrap which were just sub-marginal at the lower price are exploited for the first time. After several months of high prices, however, these sources may be exhausted depending upon whether the rate at which they are exploited exceeds the rate at which they are being replenished. If these sources of scrap are being run down, the rate at which scrap is supplied at the higher price must ultimately decline somewhat, perhaps to a new equilibrium level q_2. This new rate of supply can be sustained indefinitely because the flow of marginally accessible materials into the scrap reservoir is in balance with the rate at which such materials are removed. Prolonged periods of high scrap prices may cause the resource base to become depleted, thereby shifting the marginal cost curve upwards. This is exactly the effect which we are attempting to model when we use lagged price as a proxy for the quality of the scrap reservoir.

A third reason why our estimated elasticity might differ from the long run elasticity relates to the ability of scrap dealers to hold large inventories and thereby function as speculators. After retrieving raw scrap from the environment or purchasing loads of scrap from fabricators for as low a price as possible, scrap dealers are prepared to hold these materials for many months if necessary in order to obtain as high a price as possible. If scrap dealers perceive scrap prices to be abnormally low, inventories will accumulate. If they perceive prices to be abnormally high, they will attempt to sell as much scrap as possible in order to make a quick profit by driving down inventories.

In order to understand why this short-run phenomenon can cause our estimated elasticity to exceed the long-run elasticity we again postulate an initial equilibrium in which quantity q_o is supplied at price p_o. Demand increases drive the price up to p_1 and scrap dealers respond to this price by increasing the quantity supplied to q_1. The increase in quantity supplied, q_1-q_o, is met in two ways. Scrap dealers may intensify their collection efforts and begin recovering scrap which was not quite profitable at price p_o. Or they can begin supplying processed scrap at a faster rate than they are collecting raw scrap hence drawing down their inventories. Dealers are likely to engage in this latter kind of behavior if they perceive price p_1 to be only temporary and expect that the price will settle down again to p_o in the near future. If it turns out that p_1 is maintained, the practice of supplying scrap out of inventory will finally cease. The price p_1 will come to be perceived as the new long-run equilibrium price, and dealers will no longer see any advantage to drawing down inventories in order to sell as much scrap as they can immediately. In addition, even if after several months scrap dealers still expect the price p_o to be restored, they cannot continue to draw down inventories indefinitely.

From the above discussion it is not clear whether our estimated elasticity is greater than or less than the long-run elasticity. The fact that our observation period is too short to allow for adjustments in capital stock would tend to cause the estimated elasticity to be lower than a longer-run elasticity. On the other hand the fact that even relatively large changes in the quantity supplied during a single month may not significantly affect the availability of scrap while lasting changes will have an effect, indicates that the estimated elasticity may be higher than the long-run elasticity. Also, the fact that large monthly changes in the quantity of scrap supplied may simply represent adjustments in inventories tends to indicate that our estimate may be too high.

The question remains, then, whether we can correct for any of these biases. The equation for scrap steel, for example, contains a proxy for the availability of scrap in the environment. Conveniently enough, this proxy happens to be based upon lagged prices. Thus, a lasting price change is felt in this equation, not only as a change in present price, but also as a change in the proxy variable. By plugging into the equation a postulated permanent one percent change one can compute an elasticity that takes account of some longer-run effects. We need merely sum the coefficient for present price and the coefficient for lagged prices and compute the revised elasticity.

Still it is open to question whether this new elasticity estimate is any closer to the true long-run elasticity. If, as we have implicitly assumed, the proxy p_{lag} only captures the long-run effect of dwindling scrap availability, our problem is not solved. In this case the revised elasticity estimate does not take account of the potentially offsetting effects of long-run capital stock adjustments and short-term inventory adjustments.

What is more likely to be the case is that our proxy variable captures each of the three adjustment effects at least to some extent. However, since we do not know whether in the case of scrap steel, four months is sufficient for all three effects to work themselves out completely, it is still difficult to say with any confidence whether the revised estimate is higher or lower than the long-run elasticity. Our conjecture is that while four months of high prices is long enough for inventories to become run down and for the availability of raw scrap in the environment to decline, it is probably shorter than the period of high prices which would be necessary both to convince scrap dealers to undertake capacity expansion and to allow these expansions to actually be completed.

CHAPTER 8

IRON AND STEEL

The iron and steel industry ranks first in domestic metal production. Historically, 50 percent by weight of the iron bearing inputs used in the production of iron and steel have been scrap. It is important to note however, that only about one-fifth of this has come from obsolete iron and steel products. Also, as will become apparent below this proportion given for obsolete scrap is only an approximation. Unlike copper, aluminum and lead where industrial scrap consumption is clearly disaggregated into new scrap and old scrap, a major problem in analyzing the scrap iron and steel industry is determining what proportation of the scrap consumed during any given period comes from recycled obsolete products.

In this chapter we investigate the factors which determine the amount of scrap, and in particular obsolete scrap, which gets used in the production of iron and steel. Our ultimate aim is to predict what effect tax induced changes in the cost of obtaining virgin iron might have upon the rate at which obsolete scrap gets recycled. In section I we review the details about sources and grades of scrap iron and steel. Then we discuss the technological factors which determine the costs of retrieving scrap from the environment and the factors which affect the ease with which scrap can be used as an input in various iron and steel production processes. In section II we formulate an econometric model of the supply and demand for obsolete scrap. In section III we present and interpret the results of our econometric work. Finally, in section IV we use these results to predict the impact of tax induced changes in the price of virgin iron bearing inputs upon the rate at which obsolete iron and steel scrap is recycled.

I. MATERIALS FLOWS AND INDUSTRY DESCRIPTION

A. Sources

Iron and steel scrap is classified by source into three categories: home, prompt and obsolete.

(1) Home Scrap

Home scrap is generated at steel mills in the production of raw steel ingot and semi-finished shapes such as slabs, billets, and sheet. Ready accessability, cleanliness and known composition make this material valuable to steel makers so there has never been any problem with home scrap being discarded into the environment.

Historically home scrap has constituted about 30 percent of the total metallic feed to steel furnaces. In the event that continuous casting processes become more widely adopted this percentage will likely drop. Smaller amounts of home scrap would be recycled, simply because smaller amounts would be generated in the first place. Such a change would have no effect on either the rate at which ferrous residuals were released into the environment or the rate at which virgin sources of iron were exploited. More widespread adoption of continuous casting would increase the effective capacity of the steel industry. This could affect input use indirectly.

(2) Prompt Scrap

The category prompt scrap is composed of ferrous materials which originate as by-products in steel fabrication processes. For example, the production of automobile fenders involves cutting flat rolled sheets of steel into irregular shapes. The trimmings from this operation become prompt scrap. While it is known that most physically available prompt scrap makes its way back into the steel production process, there is some uncertainty about the exact percentage of available prompt which gets recovered. A study by the Battelle Institute estimated that 90 percent of available prompt presently gets recycled (Regan, McCleer).[1] This statistic permits an inference that scrap flows from this source could conceivably expand by slightly more than 10 percent in response to a change in the price of virgin iron. However, the 90 percent statistic and, consequently, this inference are open to question for the reasons discussed in Chapter 7 and elaborated upon below.

Determination of the rate at which prompt scrap is generated requires detailed information on the many different production processes that transform raw steel into a wide variety of intermediate and final steel products. Those statistics which do exist are only estimates based upon surveys conducted by the Battelle Institute.[2] The last complete survey was conducted in 1954 and some limited efforts have been made to update this work and apply it to the period for 1960 to 1970. However accurate these statistics may have been for the periods during which they were compiled, continuing changes in numerous production techniques, final product specifications and final product mixes introduce the possibility that these statistics do not accurately represent the present situation.

The quantity of prompt scrap recycled in any given period is also difficult to measure because existing statistics do not permit an accurate disaggregation of materials handled by dealers into prompt and obsolete categories.

(3) Obsolete Scrap

Obsolete scrap is iron and steel which is contained in industrial equipment and in consumer goods, which are no longer in use.

Such factors as product design, salvage value of components or materials other than iron and steel, disposal practices, and the geographical location of obsolete products affect the costs of recycling the iron and steel which they contain. Structural components of buildings, railroad equipment, industrial equipment and ships are generally the most readily accessible sources of obsolete iron and steel scrap. Iron and steel which is contained in these objects can be recovered and processed into a usable form relatively easily. In most cases iron and steel contained in these objects can be separated quite readily from other non-ferrous components. This cuts down on scrap processing costs. These objects provide high concentrations of iron and steel in relatively limited geographical areas. The large absolute size of ships, buildings which contain structural steel, and railroad locomotives guarantees that large quantities of iron and steel are present at a single location. Individual pieces of industrial equipment are generally found in factories of some sort and so are surrounded by other pieces of equipment, and other potential sources of scrap iron and steel scrap. The factor of geographical concentration cuts down on transportation costs. Finally some of these objects, particularly railroad locomotives and industrial equipment, contain components or material other than scrap iron and steel which have some value. Money which is obtained from the sale of these components in effect covers part of the costs of obtaining the scrap iron and steel.

Automobiles are somewhat less attractive as a source of iron and steel scrap.[3,4] This can be accounted for in terms of some of the factors listed above. Obsolete automobiles are not always present in large concentrations. Those which are, namely those which end their useful lives close to large population centers, tend to be recycled. However, the costs of recycling automobiles which are abandoned in rural areas are often prohibitively high because of high transportion costs. Like railroad locomotives and industrial equipment, obsolete automobiles do contain valuable parts which are removed from the auto hulk before it is processed as scrap. However, because automobiles are small relative to, say, railroad locomotives, the value of parts is also relatively small, so that the combined value of parts and scrap steel is not always sufficient to cover the costs of transporting an abandoned automobile to a scrap yard, dismantling it, and processing it into usable scrap.

Less valuable still as sources of scrap are household appliances. Like automobiles such objects may become locationally dispersed upon being discarded. They end up in backyards or in landfills. In general they are even smaller than automobiles so that the effort involved in collecting, dismantling, and processing a number of appliances sufficient to obtain a given quantity of scrap steel will normally be greater than the effort required to obtain the same quantity of scrap from obsolete automobiles. An additional problem thought to affect the recycling of household appliances is that many of the larger ones, e.g., refrigerators, freezers, and ranges, bear a procelain coating known in the trade as "frit". A recent study by Whirlpool and Inland steel concluded that these porcelain coatings do not constitute a significant barrier in recycling appliances.[5]

Of all major final steel products, steel cans provide perhaps the least accessible source of scrap. A single can contains only an insignificant quantity of steel. Discarded either in landfills where they are mixed in with other types of solid waste or scattered throughout the environment as litter, old cans are quite expensive to assemble into any significant quantity of steel. Other drawbacks in recovering steel scrap from steel cans relate to aspects of product design. While some cans are presently being made from tin free steel, most still contain some tin. Given existing technology and the prices of tin and scrap steel it is not economical to remove this tin, and the desirability of scrap obtained from these cans is greatly reduced. Also steel cans with aluminum tops have presented problems due to the expense involved in separating the two metallic components.

B. Scrap Grades

At the final point in the secondary materials flow cycle, where iron and steel scrap is purchased and consumed by steel mills and iron foundries, it is classified according to grade. This classification scheme is quite extensive and can be extremely confusing. All told the Institute of Scrap Iron and Steel (ISIS) lists 72 grades of processed ferrous scrap in addition to a number of railroad scrap grades and alloy scrap grades.[6] It should be pointed out, however, that a few grades account for about 80 percent of all the processed scrap which is traded. The purpose of this classification scheme is to provide a uniform set of product specifications for processed scrap which is sold by dealers to steel mills. This purpose is not fully achieved, however. There are significant regional differences, such that processed scrap which is sold in one city as a particular grade may be identical to scrap sold in another city as a different grade.

The Bureau of Mines, which reports quantities of scrap shipped to mills as well as quantities of scrap consumed at mills, has adopted this system of classification.[7] Only the most important grades are reported individually, the less important ones being lumped together under headings such as Other Scrap, Other Carbon Steel Scrap, or Other Alloy Scrap. In the Bureau of Mines reports all scrap consumed including home scrap is classified by grade. In the case of home scrap this is something of an arbitrary practice. Home scrap is not prepared by scrap dealers to conform with the ISIS classifications for the reason that it never leaves the steel mill in the first place. Assigning a given quantity of home scrap to one grade or another reflects a judgement made at the steel mill merely for the purpose of conforming to Bureau of Mines reporting requirements. So little importance is attached to such judgements that there is every reason to suspect that they are made in a rather hap-hazard fashion.

Grade classifications are based upon both the source of the scrap material and the manner in which it is prepared. Typically specifications for individual grades make mention of the source of the scrap material, size of individual pieces of scrap, the compactness or density of bundles of scrap, the presence or absence of dirt or other physical contaminants, and the presence or absence of traces of non-ferrous metals. The most preferred grades call for materials from known prompt sources that are either cut into regular sized pieces or compacted into small dense bundles, free from both physical and chemical contamination.

Several of these points can be illustrated by looking at just a few of the important grades of scrap - #1 Heavy Melting, #2 Heavy Melting, #1 Bundles, #2 Bundles, and Shredded. Together these grades account for more than 50 percent of total purchased scrap (i.e. all scrap other than home scrap). Both #1 Heavy Melting and #1 Bundles are high quality grades which must consist of scrap materials that are free from contaminants such as paint, traces of other metals and dirt. In general this implies that they are made up of prompt materials. For #1 Heavy Melting individual pieces must be no larger than 60 X 24 inches in order to insure that they can be easily charged into steel furnaces. The #1 Bundles, like all other bundled or baled scrap products, are made from compressing scrap materials into compact cubes using large hydraulic rams. The specifications for # 1 Bundles require that they be small enough to fit into the charging box of a steel furnace, and have a density of at least 75 lbs. per cubic foot.

The #2 products may contain materials that are not suitable in either #1 Heavy Melting or #1 Bundles, because of physical contamination or uncertain origins. Large quantities of obsolete materials are found in both #2 Bundles and #2 Heavy Melting. The #2 Bundles are usually made by compacting automobiles hulks which have been stripped of their more valuable parts.

Shredded scrap is produced by a hammer mill or shredder which takes entire automobile hulks and grinds them up into fist-sized bits of metal. As we shall see later on, this process converts automobiles to a processed scrap product which is superior in quality to #2 Bundles. Since its introduction in the middle 1960's it has been rapidly displacing the baling process as the primary technique for converting old automobiles to usable scrap.

C. Supply

In the preceding section we described various flows of iron and steel materials between the point at which they become available as scrap and the points at which they are re-absorbed into primary production processes. In some cases these flows involve substantially more than merely transporting and re-using discarded materials. Rather, raw scrap materials are collected and essentially manufactured into processed scrap products, which only then are suitable for use as inputs in the primary iron and steel industries. In this section we briefly describe the organization and the operations of the industry that transform raw scrap into final scrap products.

Firms which collect raw scrap and transform it into final scrap products are called processors or dealers. There are about 1,500 such firms operating approximately 2,000 facilities throughout the United States. Some of these firms make their own sales of processed scrap directly to user mills. Most deal indirectly through scrap brokers who arrange sales to user mills. Most scrap dealers are relatively small, family owned businesses, though there are a few large publicly held firms in the industry. The estimates in Table 8-1 made by the Battelle Institute give some sense of the size distribution of firms in the industry.

Scrap dealers are heavily concentrated in certain geographical areas. Particularly large numbers of scrap dealers are found in Pennsylvania, Ohio, New York, Illinois, Michigan, Indiana, California, and Texas. This would be expected because the costs of transporting raw scrap to dealers and the costs of transporting processed scrap to users are relatively high. Not only are large quantities of scrap generated in

Table 8-1. FIRM SIZE DISTRIBUTION

Annual volume	Percent of total firms
greater than 500,000 tons	0.5
300,000 - 500,000	1.0
100,000 - 300,000	1.5
60,000 - 100,000	3.5
30,000 - 60,000	7.0
less than 30,000	86.5

Source: Regan and McCleer, p. 180

the densely populated and heavily industrialized regions of these states, but also large numbers of steel mills are located in these regions. Furthermore, large quantities of scrap are exported from some of these states.

Scrap dealers' operations can be roughly divided into four categories: collection, separation, upgrading, and shipping. At one time all of these operations were relatively labor intensive. However, over the last twenty-five years, and especially in the last 10 years, major changes have occurred in the industry. Specialized pieces of capital equipment have been developed which play significant roles at most stages of scrap processing. We shall describe some of the more important kinds of capital equipment and some recently developed processing techniques in order to provide some insight into the workings of a modern scrap processing facility.

At the collection stage both truck and rail transportation have always been very important. An important innovation has been the portable automobile hulk flattener which was introduced in the mid-1960's. This piece of equipment can be moved from one place to another fairly easily. It is used to flatten entire automobile hulks prior to their shipment to scrap processors. Once flattened, up to forty hulks can be transported on a single tractor trailer, whereas only six unflattened hulks can be hauled on the same tractor trailer.

Once raw scrap is collected and delivered to dealers' yards the tasks of separation and upgrading are undertaken. The distinction between these tasks is not always perfectly clear. Often they are accomplished simultaneously and may be more properly thought of as a single task. Those operations in which heterogeneous collections of materials are sifted through and the ferrous materials segregated out, or where ferrous components are detached from pieces of equipment, can be considered part of the separation stage. Operations in which large pieces of raw scrap are reduced to manageable-sized pieces of a more homogeneous nature, or in which physical or chemical contaminants are removed, can be considered part of the upgrading stage. In some instances separation precedes upgrading while in other instances the order of these processes is reversed.

Many separation processes, especially those which precede upgrading processes, are still hand operations. Non-ferrous parts are sometimes removed by hand from automobile hulks prior to upgrading. Mixed batches of raw scrap materials, both prompt and obsolete, are often sorted through by hand. Separation processes which are undertaken after some upgrading has occurred (e.g., after an automobile has been shredded into small pieces) often make use of recently designed types of capital equipment. Magnetic separators are used to separate ferrous from non-ferrous metals, and air knives are used to separate ferrous material from non-metallic debris.

Traditionally, upgrading operations have included burning to remove organic contaminants; breaking or cutting of large, irregularly shaped pieces of scrap into smaller uniform pieces with hand operated equipment; and compacting of scrap materials into bales or bundles with the use of hydraulic rams. Advances in upgrading equipment include the guillotine shear introduced in the late 1950's and more recently the scrap shredder or hammer mill. The guillotine shear uses a hydraulically powered blade to cut pieces of steel of up to 6 inches in diameter. It is a highly versatile piece of equipment which is useful for processing a wide variety of different raw scrap materials. This versatility makes it especially valuable in small scale scrap processing facilities.

By far the most significant development in the iron and steel scrap processing industry in the past several years is the scrap shredder or hammer mill. The first of these machines began operation in 1961.

It was not until the late 1960's that shredders became at all widespread. Since that time growth of shredder capacity has been very rapid.

Objects like appliances and automobile hulks are fed into the shredder, and then, as the name implies, are shredded into fist-sized bits of metal. As compared with either of the two pre-existing methods for processing these objects, the shredder represents a substantial improvement. Formerly automobile hulks were upgraded into processed scrap either by cutting the hulk into many pieces with relatively simple tools, the most advanced of which was the guillotine shears, or by compressing the hulk into a compact bundle with large hydraulic rams (a baler).

The first of these methods, shearing, produces a high quality scrap product since once cut up the ferrous components of the auto can be completely segregated from other metallic and non-metallic parts. Shredding is capable of producing a scrap product of equal or comparable quality, since once it is shredded the ferrous component of an auto hulk can be segregated from other metals (with magnetic separators) and from non-metallic materials (with air knives). The advantage of the shredder is that it is a less time consuming and less labor intensive process than shearing processes. Where there are large numbers of autos to be processed into scrap, shredding can produce the same high quality product at a significantly lower per-unit cost.

As compared with the second method, the baling process, the shredder enjoys a quality advantage rather than a cost advantage. Both methods are highly capital intensive and the circumstances in which one method achieves lower per-unit costs than the other are not perfectly clear. However once automobile hulks are compressed, non-ferrous metals and other contaminants can no longer be separated from the ferrous materials. Therefore #2 Bundles, the scrap product made from compressing auto hulks, is judged inferior to shredded scrap.

D. Demand

(1) Introduction

Scrap in its various grades is used as an input in the production of raw steel, cast steel and cast iron. It competes in this capacity with other iron bearing inputs which are derived from virgin ores. These other inputs are often placed in two broad categories: pig iron or hot metal, iron which has been refined (reduced) in a blast furnace as the final stage in its upgrading; and pre-reduced ores, presently of minor significance, which are upgraded by means other than a blast furnace. Also of particular relevance to this report is the fact that a large amount of coke, a derivative of coal, is required in the blast furnace process which transforms iron ore into pig iron. Some limestone is also consumed in this process. In effect scrap competes with three complementary virgin material inputs. All three of these materials happen to receive favorable tax treatments which should be taken into account in computing the price advantage conferred upon virgin materials by the tax code.

The amount of scrap which is consumed should depend upon its price, the price of virgin inputs with which it competes, the level of steel production, the nature of the steel producing capital stock in place at a particular time, and the nature of existing steel producing technology. In the long run capital stock is variable and is itself determined in part by the relative availabilities of scrap and virgin inputs. For instance, if a change in tax policy raised the price of virgin inputs, we might expect to see, after a time, a relative increase in the proportion of furnaces capable of accommodating large amounts of scrap. Also technology changes over time and the particular course which this development follows will depend upon the availability of scrap and the availability of iron from virgin sources.

We shall begin with a discussion of steel production processes. This should allow us to identify the limits imposed by existing capital stock and existing technology, beyond which no further substitution of scrap for virgin inputs can take place in the short run. These limits mark the point at which short-run demand for scrap becomes entirely unresponsive to relative scrap prices, and at which tax policies which further inflate virgin prices should cease to have short run effects on the rate of recycling. Long run effects may still be felt however, since these depend upon how quickly the limits imposed by technology might themselves be expanded either by alterations in furnace capacity or by technological change.

Examination of steel production techniques should also give us a rough notion of how easily scrap can be substituted for virgin inputs within the limits of existing technological feasibility. This in turn gives us a rough idea of the amount that the quantity of scrap demanded (short-run) might increase for a given change of relative input prices in favor of scrap. Later on we will refine the estimates with the help of econometric techniques. At this point, however, it is important to get as full an understanding of iron and steel manufacturing as we can; this will aid in constructing reasonable models and properly interpreting the results of our own models as well as the models of others. It will also allow us to recognize the limits of these models so that undue reliance is not placed upon so-called "hard" or "quantitative" estimates of demand for scrap.

(2) Steel-making Processes

Steel is produced by melting iron in the form of pig iron, scrap or pre-reduced ore and driving off through an oxidation process various impurities such as carbon, silicon, manganese, phosphorous and sulfur. At the same time the molten iron may be blended or alloyed with other elements such as tin, nickel, copper, chromium, and molybdenum, which import qualities to the steel that are valuable in particular end uses.

For instance, copper improves the resistance of steel to atmospheric corrosion and increases strength.

The production process is generally carried out in one of three types of furnace: open-hearth, basic oxygen, or electric. These furnaces differ significantly in their abilities to use scrap as an input. Thus, in the short run, one would expect that existing capacities of different furnace types could help explain the demand for scrap. In the long run, as new furnaces are built to replace those that wear out, one should expect the choice of furnace type to be affected, in part at least, by the relative prices of scrap and virgin inputs.

(3) The Open-Hearth Furnace

The open-hearth furnace is very flexible in that it is technologically capable of accepting a charge of inputs composed entirely of scrap or one composed entirely of pig iron. Over the last several years open-hearth furnaces have operated on average with charges of iron inputs containing 40 percent to 45 percent scrap.[8] In open hearth production scrap and virgin inputs are not perfect substitutes distinguishable solely on the basis of relative price. Furnaces may operate more efficiently (in a technological sense) with certain balances of scrap and virgin inputs. For instance, in a "hot metal process" where scrap and molten metal are charged into the furnace, energy requirements are reduced and melt time is shortened when a higher proportion of the charge comes directly from the blast furnace in the form of hot metal. On the other hand when cold pig iron and scrap are used in a "cold metal process," energy requirements are increased as the proportion of pig is increased because of the higher amounts of carbon and phosphorous which must be driven off from the pig. Also high quantities of the metallic impurities found in scrap may deteriorate furnace linings.

While the technicalities of the input substitution process in the open-hearth furnace may affect the short run demand for scrap, over the long run we need not be so concerned with substitution possibilities. The share of steel output attributable to the open-hearth has been declining over the last ten years. This trend is expected to continue since no new open-hearth capacity is presently being constructed. It is predicted that by 1985, only 7 percent of steel output will be produced by the open-hearth process.[1] The shift away from open-hearth production has occurred because newer processes are considerably more efficient. For instance, the basic oxygen furnace produces a batch of steel in 45 minutes while the same operation takes 10 hours in an open-hearth furnace. While declining scrap prices might make the flexible open-hearth furnace somewhat more competitive with the newer technologies (that are less receptive to scrap inputs), it is unlikely that any change in input prices will reverse or even seriously retard the trend away from open-hearth production. Nor do there appear to be any potential technological improvements in the open-hearth process which might be spurred on by a drop in the relative price of scrap inputs.

(4) The Basic Oxygen Furnace

Introduced in this country in the late 1950's, the basic oxygen furnace is considerably more efficient than the open-hearth. As open-hearth furnaces have worn out over the last 15 years they have been replaced with BOF's. This trend is expected to continue in the foreseeable future.

The BOF is more limited than the open-hearth in its ability to accept scrap as an input. Presently existing technology is such that the charge of iron normally consists of no more than 30 percent scrap.[9] Whereas in the open-hearth furnace an external source of heat is used to melt the charge and induce the oxidizing reaction which drives off impurities, no external heat is applied in the BOF. Molten metal is fed directly from the blast furnace into the BOF which already contains a certain amount of cold metal. Oxygen is then injected into the molten metal at high speeds in order to stimulate the oxidation process. The reaction must proceed quite rapidly because the heat given off by the hot metal must be sufficient to melt the scrap in a very short period of time. An upper limit is thus established upon the portion of the charge which can consist of cold scrap. This limit is determined by the energy requirements for melting cold metal and the capacity of the molten metal to supply this energy. In general, molten metal is capable of melting a quantity of cold metal no more than half its own weight.

There are a number of relatively undeveloped technological procedures which permit the use of more scrap in the BOF. These are of particular interest here since the incentives to develop them might increase in response to a tax-induced decrease in the relative price of scrap. The most promising technique seems to be the pre-heating of scrap. This is an attempt to reduce the energy requirements for melting scrap which has been charged into the BOF. Rather than being added to the BOF as cold metal, scrap is heated with an external source before going into the furnace. It has already been shown to be technologically feasible for BOF's to consume up to 50 percent scrap by pre-heating the cold metal for 20 minutes.

A second possibility for increasing scrap consumption in BOF's is the use of internal fuels. Scrap and a solid fuel such as calcium carbide are charged directly into the BOF and the fuel is ignited, heating the scrap. Molten metal from the blast furnace is then added and the BOF reaction proceeds as usual except that smaller quantities of hot metal are necessary to finish melting the already heated scrap.

Other innovations include increasing the temperature of the hot metal which is added to the BOF, thereby increasing the energy available to melt the cold metal portion of the charge; and pre-heating the oxygen which is blown in during the melting cycle.

These various attempts to increase scrap usage in the BOF are mentioned to illustrate that at present it is technologically feasible to use more than 30 percent scrap in the BOF. Also in a number of cases where virgin inputs were in relatively short supply, it has become economically efficient to use charges which are more than 30 percent scrap.

No rigorous economic analysis exists which is capable of showing what input prices (e.g., for scrap, pig iron, fuels for pre-heating) are necessary before presently known pre-heating technologies become economically efficient. Nor would this tell the whole story since technology in this area is not static. Decreasing relative prices for scrap would undoubtedly stimulate efforts to find cheaper ways to use more scrap in the BOF. How successful these efforts might be is still a matter of some speculation.

(5) The Electric Furnace

In the electric furnace, inputs, usually consisting of 100 percent scrap, are placed beneath graphite electrodes, which pass a current through the cold metal. The electric resistance provided by the metal supplies the heat necessary to accomplish the melting process. Oxygen may be blown into the furnace to aid in the removal of impurities.

While there is no room for substitution of scrap for virgin inputs in electric furnace steel-making, it is still the case that declining relative prices for scrap could lead to increased scrap consumption within this sector of the industry. Electric furnace capacity is much more flexible than BOF or open-hearth capacity. Small facilities (mini-mills) can be built with a relatively small commitment of capital and can be located close to supplies of scrap. Thus it is likely that electric furnace capacity would expand in response to declining relative prices for scrap. Also there are a number of potential technological changes which might improve the efficiency of electric furnace steel-making. A decline in the relative price of scrap might hurry the development and introduction of these changes, thus making scrap even more attractive as an input to steel-making.

(6) Output Specifications - The Residual Contamination Problem

A second type of technological factor affecting the demand for scrap as an input to steel production relates to output specifications. As we described above the production of steel from iron involves both the removal of impurities and the addition of alloys. The impurities mentioned (e.g., carbon, phosphorous, sulfur, silicon) are all removed from the iron in the steel furnace. However, in addition to these there are a number of other elements (such as copper and nickel) which cannot be removed in the normal course of steel-making operations. The only way to limit the amounts of these "tramp" elements which end up in the final batch of steel is to choose iron inputs which are themselves suitably low in "tramp" content.

The problem of dealing with "tramp" elements is somewhat more complicated than what we have posed thus far. While we have been implicitly assuming that all steel output is of uniform chemical composition there are actually a number of grades of steel. The peculiar chemical composition of each grade determines the physical characteristics which make it suitable for particular end uses. Thus some grades may be higher in tramp content than others. The situation is not that some grades are simply more tolerant to tramp contamination, but rather that some grades actually require minimum quantities of these elements in order to meet specifications. Elements which are classsified as tramps in the production of some grades are the very same as the alloy elements which are blended in to impart desirable physical characteristics to other grades.

The technical constraint posed by output specifications affects the desirability of scrap as an input in two ways. First of all scrap tends to be relatively high in tramp content. One reason for this is that some scrap is derived from alloy steel. A second reason is that in the processing of scrap it is very difficult to remove all traces of other metal which may have been attached to the obsolete product from which the scrap was derived.

Since tramps are not easily removed in the steel furnace it may be necessary to dilute scrap with large quantities of virgin iron in order to bring the batch of steel up to specifications. Producers can only substitute scrap for iron in response to a shift in relative prices so long as they have not run up against the maximum limits on tramp content.

A second problem with scrap is the large variance in tramp content among shipments of the same classification. Steel producers have no guarantee that a particular batch of, say, #2 Heavy Melting scrap does not contain considerably more than the average amount of copper for this category. It is very costly to accurately analyze the tramp content of a bundle of scrap - until after it has been melted down. Hypothetically, this could cause whole batches of steel to be ruined since it may not be possible to correct for errors in judgment once the furnace cycle has begun. This is an especially severe problem with the BOF, where the entire reaction must proceed extremely rapidly in order to maintain the necessary energy balance. Furnace operators who wish to avoid costly mistakes must seek a margin of safety by consuming only small amounts of scrap inputs of uncertain quality and diluting these with virgin inputs of known composition.

The characteristics of contamination and variable quality suggest that only moderate amounts of lower grades of obsolete scrap might be consumed, and that the quantity consumed might be unresponsive to downward movements in scrap prices around present equilibrium price levels. As long as this unresponsiveness prevails, tax policies which alter relative prices of scrap to virgin inputs can have little impact upon the rate of recycling. An upgrading of the quality of scrap might improve this situation in two ways. First, even with the existing tax policy, the level of scrap consumption might rise as the scrap became more acceptable as an input; that is, demand for higher quality scrap should be greater than for low quality scrap. Second, changes in relative prices induced by tax policies, might have a further pronounced effect upon the amount of scrap consumed; that is demand for better quality scrap might be more elastic than demand for low quality scrap.

The introduction of the automobile shredder is an example of a technological change which in effect transforms auto hulks into a different product for which demand is higher and probably more elastic. The shredder opens up a source of high quality scrap in the following way. The steel going into automobile bodies must be flexible and capable of being rolled into thin sheets. Such physical characteristics are achievable only with steel that has an extremely low alloy content. Compared with scrap from obsolete industrial equipment, made of lower grade steel, auto scrap has always been potentially superior. In spite of this the grade of scrap previously derived from obsolete automobiles (#2 Bundles) was judged inferior to that derived from old industrial equipment, the reasons for this being that scrap processing methods such as baling create a product in which the other metallic parts in the auto hulk become mixed in with the steel. The amount of steel in a single auto hulk does not justify the removal by hand of all other metal parts before the car is processed. Usually a car is stripped only of those parts which are resalable or which are particularly easy to remove. Auto hulks containing other metals are simply compressed into compact bundles which can be easily transported and fed into steel furnaces. Once these bundles are compressed it becomes impossible to physically separate the steel from tramp metals such as copper. Consequently the substance derived when these bundles are melted down in the steel furnace contains high percentages of tramp elements.

Shredding on the other hand breaks an auto hulk into fist-sized pieces. These bits can be separated magnetically so as to reduce tramp contamination in the scrap product. Autos which are shredded achieve a quality and command a price comparable to that of #1 Heavy Melting, a better grade of scrap.

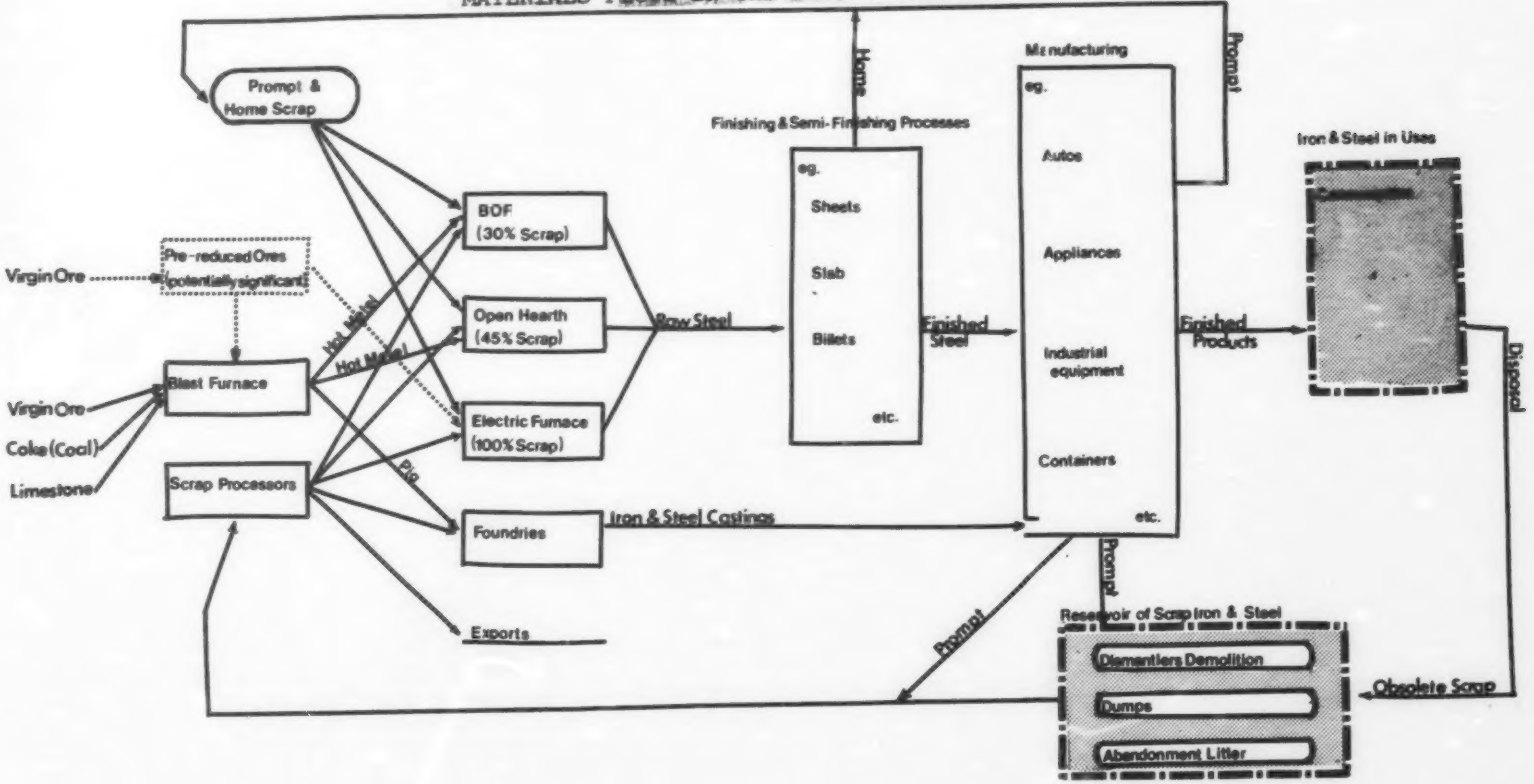
(7) Iron and Steel Foundries

Iron and steel foundries use scrap and pig iron to produce a wide variety of ferrous castings. These products fall into three general categories: gray and ductile iron castings, malleable iron castings and steel castings. Also there are three technologies in use which account for almost all foundry output. The cupola furnace is responsible for about 90 percent of cast iron production. The electric furnace provides the remainder of cast iron output as well as about 70 percent of cast steel output. The other 30 percent of cast steel production comes from open-hearth.

The casting sector accounts for approximately 20 percent of annual domestic consumption of scrap iron and steel. Unlike raw steel production there are no strict technological limits upon the amount of scrap which can be used. All three processes are capable of receiving charges that consist of 100 percent scrap. While these facts suggest that foundry consumption of scrap might be highly responsive to a drop in its relative price, no significant increase in scrap consumption is likely to occur in this sector. This is because scrap inputs are already such a large percentage of total iron inputs that little room is left for further substitution of scrap for virgin. Electric furnaces already use input charges that are close to 100 percent scrap. Cupola furnaces can use shredded, but not #2 Bundles, in charges that average 85 percent scrap. Open-hearth furnaces operate with inputs that are 90 percent scrap.

Nonetheless, possibilities for substitution do exist. In the short run cupola furances could accept even higher charges of scrap than they

Figure 8-1
MATERIALS FLOWS IN THE STEEL INDUSTRY


Prompt & Home Scrap
Virgin Ore
Pre-reduced Ores (potentially significant)
Blast Furnace
Virgin Ore
Coke (Coal)
Limestone
Scrap Processors
Hot Metal
Hot Metal
Pig
BOF (30% Scrap)
Open Hearth (45% Scrap)
Electric Furnace (100% Scrap)
Foundries
Exports
Raw Steel
Iron & Steel Castings
Home
Finishing & Semi-Finishing Processes
eg.
Sheets
Slab
Billets
etc.
Finished Steel
Manufacturing
eg.
Autos
Appliances
Industrial equipment
Containers
etc.
Prompt
Finished Products
Iron & Steel in Uses
Disposal
Obsolete Scrap
Prompt
Prompt
Reservoir of Scrap Iron & Steel
Dismantlers Demolition
Dumps
Abandonment Litter

do now. There has been a clear trend towards increased scrap consumption (Regan, McCleer).

II. ECONOMETRIC MODEL

A. Introduction

For this report it is most important to obtain estimates of how the quantity of scrap supplied responds to changes in its own price, and how the quantity demanded responds to changes in the cost of obtaining pig iron, the principal virgin substitute for iron and steel scrap. Also of considerable interest is the relationship between the quantity of scrap demanded and its own price. Econometric techniques were used to estimate supply and demand equations for iron and steel scrap to provide quantitative measures of these parameters.

In this study we are most concerned with that portion of iron and steel scrap which is actually retrieved from the environment, rather than that which is automatically recovered as part of the ordinary steel production cycle. The portion which we are interested in includes all obsolete scrap. It also includes some small but unknown portion of prompt scrap which gets released into the environment when scrap prices are low, instead of being recycled immediately or held by scrap dealers or metal fabricators in anticipation of higher prices.

Separating the flow of automatically recovered pig iron and steel scrap from the remaining portion represents a major problem encountered in the course of this study. Ideally, one would like to have two separate data series in order to estimate supply equations for each category. Unfortunately, this procedure could not be followed. In part, this is because of the poor quality of the data. Statistics which would permit separation of all prompt from all obsolete scrap are not even kept. In addition, there are conceptual difficulties in drawing a line between high quality secondary materials which are returned to steel mills through what is essentially a series of exchanges, and secondary materials which have actually been "produced" from raw scrap.

Two strategies were employed to meet these difficulties so as to disentangle the impact of prices upon quantity of scrap supplied from the "reservoir" of discarded iron and steel from the impact of prices upon the rate at which high quality prompt flows back to steel mills. The first of these approaches involved using what seemed to be the most consistent reliable series of quantity data, that for total purchased scrap, even though this category is overly broad. Total purchased scrap includes all obsolete scrap as well as all prompt scrap. A more desirable series would exclude most of the prompt scrap, since this falls into the category of high quality materials that would be returned to steel mills or iron foundries in a short time under any reasonably anticipated set of circumstances. The supply equation for this broad category was specified to include non-price variables which affect the amount of automatically recovered material which is received at steel mills in each period, thus accounting for the prompt portion included in the total purchased scrap series.

The other strategy for estimating the price responsiveness of iron and steel scrap was to work directly with more highly disaggregated data. For this report the quantity series for individual grades of scrap were used (see Table 8-2). The advantage of this method is that the non-price factors which influence the rate at which easily accessible prompt scrap flows back into the steel production sector could be ignored. A disadvantage is that it is very difficult to obtain consistent data series which report the same quantity, spanning any appreciable length of time.

The modeling efforts proceed as follows. In Section B we state the hypothetical supply and demand relationships for iron and steel scrap, listing the factors to be included in each relation. These relationships are then elaborated in Section C, "Variables," where the theoretical basis for each is developed. In addition, there is some discussion of the appropriate measures for each variable employed in the supply and demand relationships, and of the data which is available for testing each hypothesis in the context of a supply-demand model. Finally in Section D this discussion is drawn together as we present the models which were actually tested.

B. Hypotheses

It was postulated that the quantity of scrap supplied to domestic consumers during any one month depends upon:

1. Price of processed scrap.
2. Activity in the scrap export market.
3. State of technology and the quality of capital stock in the scrap industry.
4. The availability and accessibility of the raw scrap inputs which scrap dealers collect and prepare for sale to the steel industry.

It was postulated that the quantity of scrap demanded by domestic consumers depends upon:

1. Price of processed scrap.
2. The level of activity in the steel industry, the sector which consumes scrap.
3. The price to steel manufacturers of obtaining pig iron, the virgin input with which scrap competes in steelmaking.
4. The composition of the steel industry's capital stock - different kinds of steel furnaces vary in their abilities to accept scrap inputs - and the state of technology in the steel industry.

Others have developed econometric models which encompass the scrap steel industry In particular, we note the work of Adams[4] (a primitive model), Higgins,[10] Johnson,[11] and Russell and Vaughan[12] (a process or engineering approach).

C. Variables

(1) Quantity of Scrap

As discussed previously, one may identify two loosely defined categories of iron and steel scrap: 1) materials which are automatically recovered as part of the steel production and fabrication process, and 2) materials which are retrieved or diverted from the environment only with the expenditure of some significant amount of effort. Home scrap falls into the first category. It is 100 percent recycled, and would continue to be recovered regardless of the price of scrap. Obsolete scrap falls into the second category. It is retrieved from the environment only when scrap prices are high enough to defray the cost of this activity. Conceivably, the price of scrap could drop to a level where no obsolete scrap was supplied at all. At this hypothetical low price it would be unprofitable for private individuals to collect and process even the most accessible obsolete scrap.

Prompt scrap is less easily dealt with in terms of these categories. There is some indication that a portion of prompt material, perhaps ten percent, is not recovered other than during periods of extremely high prices. Clearly, this portion falls into the second category. On the other hand, the highest quality prompt scrap is certainly in the first category. It is presently collected at fabricating plants and returned to steel mills as a routine part of the production cycle. This is a practice which should continue, barring only the most major change in steel-making technology or input costs. It is impossible to say exactly how much prompt material fits into this category, but for the purposes of this study it is sufficient to recognize that not all prompt scrap is automatically recovered.

This investigation is concerned with the supply and demand of scrap which falls into the second category. This includes all obsolete scrap and that portion of prompt material which is recovered only during periods when scrap prices are high enough to compensate individuals or firms for the efforts required to divert or remove such material from the environment.

The first problem which one encounters in trying to estimate these relationships econometrically is obtaining an appropriate data series for quantity of scrap. Ideally, one would want to work with quantity figures which did not include any high quality automatically recovered material, but which did include all obsolete and low quality prompt material. Such a data series is difficult to construct for two reasons. First some automatically recycled scrap follows the same materials flow paths as obsolete scrap, and thus is included in the figures reported for this latter category. Second, even the series which records the movement of materials of both types through these flow paths has not been kept with any consistency. Both of these points will be developed below.

Monthly statistics on iron and steel scrap are reported by the Bureau of Mines in the publication Monthly Mineral Industry Surveys. The first point in the secondary materials flow at which statistics are reported is where scrap is received by steel mills and iron and steel foundries: scrap receipts. After this, statistics are reported for quantities of scrap consumed in primary production processes. In general, data at this later stage are less useful because these figures include varying amounts of home scrap which, never having left the mill, were not included with receipts.

There are no published figures on materials flows into scrap dealers' yards, nor on inventories held by scrap dealers. In addition, there is not a continuous data series on quantities of scrap which bypass dealers altogether and are shipped directly from fabricators' plants back to steel mills. Were any of these data available, they would be quite valuable for purposes of identifying by source (e.g. obsolete, automatically recycled prompt, or marginal prompt) scrap which is supplied to the primary steel industry. Also these data would be valuable for purposes of distinguishing fluctuations in the quantity of scrap supplied which are introduced by speculative behavior on the part of scrap dealers, from fluctuations which reflect changes in the level of effort expended in collecting and processing scrap.

Reported receipts of scrap at steel mills are broken down by scrap grade, the industry's classification of scrap dealers' outputs. This categorization is based upon the quality which scrap achieves after it has been processed by dealers. Because quality at this point is a function of both the source of the material as well as the amount of processing it has received, it is not possible to divide scrap grades into those which contain only automatically recycled material and those which contain only obsolete and low quality prompt material. Nor is it possible to separate all prompt scrap from all obsolete scrap. Most grades include at least some material from a number of different sources.

While industry classifications of scrap grades do not permit a perfect breakdown between scrap from high quality sources and scrap from low quality sources, a fairly close approximation should be possible. There are just a few grades which account for a major proportion of all iron and steel scrap. Among these important grades are #2 Heavy Melting, and #2 Bundles which are derived mostly from low quality scrap materials. Recently, shredded scrap has become relatively more important. It is derived exclusively from obsolete scrap materials, mainly junked automobiles. It seemed reasonable to examine these grades either individually or taken together, and to attempt to fit them into a simple supply-demand model. While this model would only be based upon part of the market for iron and steel scrap from low quality sources, it would probably be acceptable as a basis for inferences about the entire market for obsolete and low quality prompt material.

Unfortunately, over the past several years, the Bureau of Mines reporting of these grades has been so inconsistent as to make any time-series analysis extremely difficult. During the years 1963 through 1967 the classification #2 Heavy Melting was dropped from the reporting system altogether. Just prior to 1963 steel mills had been reporting receipts of approximately 200,000 tons per month of #2 Heavy Melting. This quantity accounted for a significant portion of scrap from low quality sources. Starting in January 1963, no figures were reported at all for #2 Heavy. This ommission was due to the fact that survey forms sent out to steel mills and iron and steel foundries no longer included #2 Heavy Melting as a category. Respondents to survey forms decided for themselves where to include these receipts among the other grade classifications still appearing on the forms. Large quantities of this material seem to have been included with #2 Bundles as there is an abrupt jump in the reported figures on #2 Bundles received in January 1963. Unfortunately, this jump accounts for only part of the deleted quantity of #2 Heavy Melting so that it may not be appropriate to interpret 1963 to 1967 figures on #2 Bundles as giving the sum of #2 Bundles and #2 Heavy Melting. Thus, besides a gap in the series on #2 Heavy Melting, stretching from 1963 through 1967, it is also the case that figures on #2 Bundles over this period are not strictly comparable to any series or combination of series reported either before or after those years.

Starting in 1968, reporting of #2 Heavy Melting as a separate category was resumed. However, at the same time another change was made in the reporting system which acts as an obstacle to this investigation. From 1968 through 1971, the Bureau of Mines stopped reporting statistics on scrap receipts for individual grades and instead gave only consumption figures. The difference between receipts and consumption is accounted for by inventory changes within steel mills and by consumption of home scrap which mills are also asked to classify by grade. Inventory changes are small relative to total receipts. However, an examination of those years when both consumption and receipts are listed showed that home scrap classified as #2 Bundles and #2 Heavy Melting was often as much as one quarter of the total consumption for each of those grades. The home component in these categories also fluctuated rather widely and it was not a constant proportion of consumption in either of these categories.

Nor was there any significant relationship between the quantity of home scrap consumed in one period and variables measuring the level of steel production activities which generate home scrap either in the same period or in preceding periods. As a result, it was difficult to use data for periods in which receipts and home scrap were reported separately as a basis for making inferences about the quantity of home scrap included in each month's total consumption statistics for the period 1968-1971.

What is left is a number of fragmented series on receipts of the lower grades of scrap. The years 1963 through 1967 provide a consistent series for receipts of #2 Bundles and after 1972 there are data on receipts for all three grades. Consumption data is available over longer periods, at least for #2 Bundles. However, because of changes in the way scrap materials are classified among different grades in the Bureau of Mines Reporting System, consumption figures prior to 1968 are not comparable with figures after that time. Moreover, consumption statistics are not really appropriate for purposes of this report because they include significant and unpredictable amounts of home scrap.

The poor quality of data for separate grades of scrap forces a heavy reliance upon the series for total scrap receipts, which includes all obsolete and all prompt scrap. This category is obviously broader than desired. However, it is the only data series which has been kept with any consistency over the past several years. Also, while it does include large quantities of automatically recycled prompt scrap, at no point does it include home scrap which is the most easily recovered of all secondary iron and steel material.

TABLE 8-2

DATA AVAILABILITY

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
Receipts #2 Bundles	■	■	■	■	■	■					■	■	■
Consumption #2 Bundles	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨	▨
Receipts #2 Heavy Melting	■										■	■	■
Consumption #2 Heavy Melting	▨						▨	▨	▨	▨	▨	▨	▨
Receipts Shredded							■	■	■	■	■	■	■
Consumption Shredded							▨	▨	▨	▨	▨	▨	▨
Total Receipts of Scrap	■	■	■	■	■	■	■	■	■	■	■	■	■

(2) Price of Scrap

Prices for various grades of scrap are posted by user mills. The posting of a price indicates a willingness of that user to accept all deliveries meeting grade specifications at that price. Generally, transactions take place between scrap consumers and the scrap brokers who have collected and processed the raw scrap into a more easily transportable and easily usable form. In some cases, however, the dealer is bypassed, and sales are made directly by large scrap generators such as auto manufacturers to scrap consumers. In either case, brokers may intermediate in these transactions.

Scrap prices are quoted daily in a number of cities, and then reported on a monthly basis in various trade publications such as American Metal Markets and Iron Age. These quoted prices often serve as benchmarks from which negotiations between buyers and sellers proceed. They are generally regarded as having been determined by competitive forces since buyers and sellers are relatively numerous, and as giving a close approximation to the prices at which scrap is actually traded on a particular date and at a particular location. This is most certainly true for lower grades of scrap, most of which is bought and sold in transactions calling for delivery within thirty days. Quoted prices may be somewhat less accurate, however, for some higher grades of prompt scrap, especially where the scrap, bypassing dealers, is sold directly to users. Often these sales are part of long term contracts, and, in some cases, the return of such prompt scrap by fabricators is arranged in these contracts as part of the initial sale of steel to these fabricators. In these situations, the reported prices on a given date may diverge somewhat from the previously agreed upon price at which some scrap is actually traded. Nonetheless, the reported scrap prices were regarded as giving a fairly accurate representation of the cost to users of obtaining scrap. The price series used were the Bureau of Labor Statistics Price Indices for Iron and Steel Scrap, deflated by the Wholesale Price Index for all commodities. The composite price index for iron and steel scrap was used when the dependent variable was total receipts of scrap. The scrap index for #2 Bundles was used when the dependent variable was receipts of #2 Bundles.

(3) Technological Change in the Scrap Industry

The data period we are using was one in which there was significant technological change in the scrap iron and steel industry. Improvements were made in existing kinds of equipment such as shearers which are used by smaller scrap processors. Far more important were the introduction and spread of the automobile hulk flattener and the shredder. The portable flattener compresses automobile hulks before they are shipped off to scrap processors. Transportation costs, which are a major component of the cost of supplying processed scrap, are thereby substantially reduced. The shredder was introduced in the middle 1960's and seems to be replacing baling and shearing as the most efficient method of preparing processed scrap from raw scrap inputs, particularly automobile hulks.

Unfortunately no time series data were available which would have allowed us to directly track the adoption of these technological innovations. We were unable to obtain statistics on either shredder capacity or the number of shredders in use at various times. Also we were not able to obtain statistics on the number of flatteners in operation. Lacking this data, a time trend was inserted as a proxy for technological change over this period.

(4) Scrap Exports

Exports were used as an independent variable in the supply equation. They were treated as an exogenously determined quantity that caused a parallel shift in the supply curve. This treatment of exports was based upon the simple hypothesis that a ton of scrap exported reduces by one ton the quantity of scrap which is made available to domestic consumers at a given price. Thus when exports are high, large quantities of scrap are being drained off from domestic markets and the domestic supply curve shifts backward toward the vertical axis. When export levels are low, the domestic supply curve shifts outward as larger quantities of scrap become available on domestic markets.

Obviously this model oversimplifies things to a considerable extent. Scrap which is exported does not just disappear from the market. Rather it is sold to foreign buyers for a price which in equilibrium tends toward the American price. The quantity sold abroad is determined simultaneously by a total supply equation which includes domestic supply plus exports, a domestic demand equation, and a foreign demand equation. Foreign demand, in turn, is a function of activity in foreign steel industries, the value of the dollar measured against various foreign currencies, as well as U.S. and foreign scrap prices. A more complete model of the U.S. scrap industry would have to take into account these factors and would include at least two separate demand equations, one for domestic demand and one for foreign demand. It might be necessary to break down foreign demand even further among some of the larger scrap importing countries. Because of time and data constraints, the decision was made to dispense with foreign demand equations. There was no data available to explain historical export patterns for scrap, nor was there information with which to forecast future trends in foreign demand for scrap.

The treatment of exports used in this study assumes that foreign demand is determined independently of domestic prices and moves only in response to factors such as activity in foreign steel industries and fluctuations in foreign exchange rates. To the extent that this assumption is correct, a model which uses quantities supplied to domestic consumers is appropriate for purposes of forecasting the environmental effects of an increase in domestic demand for scrap. If foreign demand is completely inelastic, any increase in the quantity of scrap consumed domestically which might result from a tax induced outward shift in the domestic demand curve must come entirely from scrap which would not otherwise have been recycled. Each additional unit of scrap going to domestic consumers is an additional unit removed from the environment.

On the other hand, if foreign demand is not inelastic, then as domestic demand shifts outwards, the increase in quantity supplied to domestic consumers will be greater than the increase in quantity supplied to all consumers. Only some of the additional scrap going to domestic consumers will come from net additions to the quantity of scrap recycled.

Since an additional unit of scrap to domestic consumers is not an additional unit removed from the landscape, the environmental effect of a tax policy change would be less pronounced than the model used might suggest.

(5) Availability of Raw Scrap

The supply of processed iron and steel scrap is affected by the availability of obsolete products which contain iron and steel, and by the availability of ferrous by-products from metal fabricating processes.

As a proxy for the availability of obsolete products we used a four month distributed lag on iron and steel scrap prices. The rationale for this approach was developed in Chapter 7. Briefly, we postulated that if scrap prices were high in recently past periods intensive collection efforts would have been undertaken, leaving the reservoir of obsolete iron and steel products relatively depleted. Conversely, low scrap prices would have stimulated less intensive collection efforts, leaving larger quantities of accessible iron and steel products available for collection in the present period.

The availability of ferrous by-products from metal fabricating processes, or raw prompt scrap, was represented by a composite index based upon levels of activity in a number of prompt generating sectors. Production levels in these sectors should be directly related to the quantity of prompt scrap which is generated each month. In turn, the quantity generated during one month should have some effect upon the scrap supply curve in succeeding months. The index used was constructed as a weighted average of the Federal Reserve Indices for automobile production, production of industrial equipment, production of appliances, and production of transportation equipment. Automobile production received a weight of 1/2 and the other three indices received weights of 1/6. This weighting scheme was suggested by estimates reported in various issues of the ISIS Yearbook of the quantities of prompt scrap generated in various sectors. A one month lag was used.

(6) Activity in Scrap Consuming Sectors

The demand for scrap in any period is related to the levels of activity in those production processes that consume scrap as an input. These processes include: 1) the production of raw molten steel (which is either hardened into ingots or formed immediately into semi-finished shapes in continuous casting operations), 2) the production of steel castings, and 3) the production of iron castings. Also small amounts of scrap are sometimes charged directly into blast furnaces which reduce iron from its ore.

Production figures which encompassed steel and steel castings were used to represent a composite activity level for all scrap consuming processes. This treatment does not take explicit account of the iron foundry sector. However, it seemed justified, for the sake of convenience, on the grounds that 1) by far the largest quantities of scrap go into the production of raw steel and steel for casting (about 85 percent of total scrap consumption) and 2) activity in the non-integrated foundry sector generally parallels activity in the steel industry.

Data were taken from the American Iron and Steel Institute's series on raw steel production, which covers both raw steel and steel castings.[13]

Further research efforts might attempt to use a more detailed breakdown of demand exerting activities. Demand by the iron foundry sector could be examined separately from demand by steel producers. Also within the steel industry demand for scrap is affected by the mix of steel output being produced. For instance scrap can be used much more easily in the production of alloy steels than in the production of carbon steel.

There has been some increase in alloy steel production as a percentage of total raw steel production over the last 15 years (7.5 percent in 1960 to 10.7 percent in 1973). With other factors remaining constant this should have caused some increase in the demand for scrap. At the same time however, there were changes in the product mix which should have dampened scrap demand: flat rolled products which require the highest quality carbon steel increased as a percentage of finished steel products. Only small amounts of scrap can be used in the production of these high quality carbon steels.

(7) Price of Pig Iron

According to economic theory, the demand for scrap should depend upon the cost of virgin based substitutes; these include pig iron and pre-reduced iron ore pellets. Since pre-reduced ores have not competed on a wide scale in the past they need not be considered any further at this point. Substitution between scrap and pig iron (both as solid "merchant pig" and as molten "hot metal") occurs either through altering the mix of inputs to particular production processes, or through switching among production processes that consume scrap and virgin materials in different fixed proportions.

Unfortunately, it is difficult to obtain a reliable indicator of the real cost of pig iron. There are basically two reasons for this. First, most hot metal is consumed by large integrated firms which supply their own needs. At least 90 percent of the pig iron produced is never traded in the market. Most of this is simply poured directly from a blast furnace into an adjoining steel furnace while it is still in a molten state. There is some question, then, of whether the market price at which the remaining 10 percent of cold "merchant pig" is traded, accurately reflects the real short-run marginal cost to an integrated steel producer of supplying himself with "hot metal". This question persists, even assuming that the market price for pig is competitively determined and is accurately reported.

A second obstacle to obtaining accurate estimates of the real cost of pig iron is caused by the nature of the "merchant pig" market itself. The number of sellers in this market is small enough to arouse the suspicion that it is not a perfectly competitive market. There are about 30 firms operating blast furnaces in the United States (AISI Directory of Iron and Steel Works of the U.S. and Canada). Therefore, it is hard to tell whether, or by how much, prices diverge from those which would prevail under pure competition. What is clear, however, is that list or reported prices are not competitive. List prices change very rarely, and it is generally held that they do not represent the price at which pig iron is actually traded. During periods of blast furnace overcapacity there may be substantial discounting below the list price. During periods of shortage, list prices may be exceeded. In addition, rationing may occur either at the reported price or at prices above this level.

Despite these shortcomings, list prices for pig iron were used in the demand equation for scrap in an effort to measure the cross-elasticity of demand for scrap with respect to virgin materials prices. The series used was the B.L.S. price index for pig iron and ferro-alloys. The main justification that can be offered for this procedure is that of necessity: no series exists for either actual transaction prices or for the internal accounting prices for pig iron which is not traded on the market.

As an alternative to relying on reported pig iron prices, an attempt was made to construct an index which more accurately reflected the marginal costs to integrated steel producers of obtaining virgin hot metal. Our efforts were based on the assumption that the marginal cost of obtaining pig iron rises as blast furnace output approaches 100 percent of capacity. Proceeding from this assumption we first attempted to obtain figures for blast furnace capacity. Unfortunately the only source for these figures, the AISI Statistical Yearbook, stopped reporting them in 1960. Since 1960, only statistics such as numbers of blast furnaces in and out of blast, new additions to the blast furnace stock and numbers of furnaces permanently shut down have been kept. These were of no help in estimating the trend in furnace capacity, however, because technological advances during the 1960's tended to increase the capacity of even those blast furnaces already in existence.

Finally we made our own estimate of blast furnace capacity. Monthly production statistics for 1959 through 1974 were arrayed, and a number of peak production months were identified. A brief survey of the trade journals for these months turned up statements to the effect that blast furnaces were operating at 100 percent of capacity. A linear trend was then fit through these points and monthly furnace capacity was estimated by interpolating along this line. Some confirmation of the accuracy of this technique was provided by comparing our estimates for years prior to 1961 with figures reported in the AISI yearbook. In all cases estimated capacity came within two percent of reported capacity.

Using our estimates of blast furnace capacity, a capacity utilization series was computed and included in the demand equation as a proxy for the price of pig iron. In addition we experimented with a number of transformations of this index. These transformations were based on the notion that marginal costs are constant up until some level (around 80 percent capacity), and then rise at an increasingly rapid rate as capacity utilization approaches 100 percent.

These proxies had t-ratios below unity in the estimated demand equation and were dropped from further consideration.

(8) Technological Change in Scrap Consuming Sectors

The introduction and spread of the basic oxygen furnace (BOF) over the last fifteen years is frequently cited as a factor which has dampened the demand for scrap. This hypothesis is based on the fact that substitution of scrap for virgin inputs is more tightly constrained in the BOF than in the open-hearth furnace which preceded it as the predominant steel-making technology. While scrap does not substitute perfectly for pig-iron in the open-hearth furnace, it is at least technologically feasible to use a charge of 100 percent scrap. Actual furnace charges have averaged about 55 percent virgin and 45 percent scrap. On the other hand, until recently there has been an assumed upper limit of 30 percent on the proportion of scrap which can be used in a BOF. Presently, some firms are employing techniques such as preheating scrap, which decreases the virgin hot metal requirements of the BOF and allows the 30 percent limitation to be exceeded. However, these practices were not widespread during the period analyzed in this study.

The extent of the changeover from the open-hearth to the BOF between 1962 and 1972 was significant. In 1962 the percentages of raw steel production from the BOF and from the open-hearths were, respectively, 5.6 percent and 84.3 percent. By 1972 the percentage from the BOF had risen to 55.9 percent, and that from the open-hearth had dropped to 26.2 percent.

Tending to counteract any effect that this trend might have had on the demand for scrap was the increase in electric furnace capacity over these years. Small electric furnaces, operated by non-integrated firms, have opened up throughout the country. These furnaces, which use scrap as the only iron bearing input, are especially concentrated near large sources of scrap.

Electric furnace production as a percentage of total raw steel output has expanded from 8.8 percent in 1962 to 17.3 percent in 1972. It is not unlikely that this development was actually a consequence of the adoption of BOF technology by the large integrated mills. As the integrated mills decreased their consumption of purchased scrap, electric furnaces sprang up and took advantage of the temporary excess supply of scrap.

Some effort was made to test the hypothesis that the introduction of the BOF caused the demand curve for scrap to shift backwards. Assuming that growth of BOF capacity was itself independent of scrap prices, the proper way to test the hypothesis would be to include BOF capacity or BOF capacity as a percentage of total capacity as an independent variable in the demand equation. It seems fair to say that the growth of BOF capacity was in fact largely independent of scrap prices. BOF's were brought on line by integrated producers to replace worn out open-hearth furnaces and to expand total capacity. During this period, no new open-hearth furnaces were built. At most scrap prices may have had some effect on the timing decision of when to close down marginal open-hearth furnaces. However, it is unlikely that this significantly influenced the timing of investment decisions in BOF capacity.

Unfortunately, there is no data available on steel furnace capacities. As a proxy for BOF capacity, the percentage of total yearly steel output produced in BOF's was used. Obviously, this is not a perfect proxy. It will be relatively accurate during periods when capacity utilization is high for all furnace types. However during periods of slack demand, when excess capacity exists, it is not necessarily the case that all furnace types operate at the same percentage of capacity. If there are unequal utilization rates among different furnace types, the validity of this proxy is questionable.

There are two reasons for expecting capacity utilization rates to differ among furnace types during periods of slack demand. First, open-hearth furnaces are all older than BOF's. When demand drops off there is probably some tendency for the largest cutbacks in production to come from older, marginally efficient furnaces. Since those all happen to be open-hearth facilities, BOF production as a percentage of total production would overstate BOF capacity as a percentage of total capacity when capacity is underutilized.

A second reason why capacity utilization may differ among furnace types is that utilization rates may be affected by the relative prices of scrap and virgin inputs. While it was argued above that decisions to invest in BOF capacity were largely independent of input prices, operating decisions are probably tied more closely to relative input prices. When scrap prices are low, the flexible input capabilities of the open-hearth furnace make it relatively attractive as a production technology. At higher scrap prices the cost advantages enjoyed by the open-hearth associated with its ability to consume larger proportions of scrap become less significant.

Recognizing the limitations of proxies which are based upon actual production rather than furnace capacity, we proceeded to include in our demand equation a variable which reflected the adoption of basic oxygen technology to test whether the trend towards increasing BOF capacity affected the demand for scrap. Data was obtained from various volumes of the AISI Statistical Yearbook. A number of proxies were tried including BOF production as a percentage of total steel production, and open-hearth production as a percentage of total steel production. None of these variables had t-ratios of 1.5 or more and were finally dropped from the demand equation. This result may have been due to the limitations in the data pointed out above. However, it is also consistent with the hypothesis that the concurrent spread of electric furnace capacity tended to mitigate any effect that the introduction of the BOF may have had on the demand for scrap.

D. Models

The preceding discussion can be summarized in terms of two simple supply-demand models given below in implicit functional form.

Model I

$$Q_s = Q_s\ (P_{scrap}, Av_1, Ex, T_{scrap}) \tag{14}$$

$$Q_d = Q_d\ (P_{scrap}, P_{pig}, Q_{steel}, T_{steel}) \tag{15}$$

where, Q_s, Q_d = quantity of scrap purchased by domestic consumers which is derived from obsolete and low quality prompt materials

P_{scrap} = price of scrap

Av_1 = availability measure for unprocessed, uncollected scrap originating from obsolete and low quality prompt sources

Ex = quantity of scrap exports

T_{scrap} = the state of technology in the scrap industry

P_{pig} = the cost of obtaining pig iron

Q_{steel} = the level of activity in scrap consuming sectors

T_{steel} = technological factors in the steel industry which affect the ease with which scrap is used as an input.

Scrap prices and scrap exports are for the particular grades of scrap included in Q_s and Q_d.

Model II

$$Q_s = Q_s\ (P_{scrap}, Av_1, Av_2, Ex, T_{scrap}) \tag{16}$$

$$Q_d = Q_d\ (P_{scrap}, P_{pig}, Q_{steel}, T_{steel}) \tag{17}$$

where, Q_s, Q_d = total quantity of scrap purchased by domestic consumers

Av_2 = availability measure for automatically recovered prompt scrap

The price of scrap is a composite for all grades, and Ex is total scrap exports.

The supply equation in Model I is based upon the idea that scrap processors are engaged in production from a resource base which consists of discarded iron and steel materials or raw scrap. Scrap prices determine the level of effort expended in exploiting this resource base. Competition in the scrap industry implies that effort is adjusted to the point at which the marginal cost of retrieving and processing the last unit of scrap is equal to the price obtained for processed scrap.

The quantity of scrap which actually gets supplied thus depends upon both the price of scrap and the amount of raw scrap in the environment which can be collected, processed and sold at a profit for the existing price. Changes in the availability and accessibility of raw scrap over time will cause the quantity which gets supplied at each price to change. Put another way, changes in the characteristics of the resource base will lead to shifts in the supply curve for scrap.

In Model II the quantity variable includes not only materials which are retrieved from the environment, but also materials which are automatically recovered in the course of the steel production cycle. In order to control for changes in Q_s, which represent variations in the flow of automatically recovered material, a second availability measure, Av_2, is included as an independent variable in the supply equation. This availability measure is based upon past activity levels in the metal fabricating sectors which generate high quality automatically recovered prompt scrap.

Since both supply equations are for quantities of scrap going to domestic consumers, both include scrap exports as an independent variable in order to account for shifts in domestic supply curve brought on by changes in export levels. Our hypothesis is that exporting scrap reduces the quantity which will be made available to domestic consumers at any given price, thereby shifting the supply curve backwards.

Technological changes in the scrap iron and steel industry which have affected the costs of collecting and processing scrap are taken into account as is indicated by the variable T_{scrap}.

The two demand equations which are essentially the same are based on the notion that demand for scrap is tied to the production of steel. These equations included the variable Q_{steel} which represents the level of production in the steel industry. Also included are P_{scrap}, the price of scrap, and P_{pig}, the price of pig iron, which is the competing virgin substitute. It is assumed that the level of steel production is independent of the two input prices. Finally the inclusion of T_{steel} indicates that we have attempted to take account of technological changes in steelmaking which are purported to have affected the demand for scrap.

III. ECONOMETRIC RESULTS

Initially the most elementary functional forms were selected for both supply and demand. Each function was assumed to involve a linear additive relationship between the independent variables and the dependent variable. This specification seemed appropriate as a starting point given that we are working with what is basically a static supply and demand model of price and quantity determination, with several exogenous variables which represent factors that may cause either the supply curve or the demand curve to shift from one period to the next. Modifications of these functional forms were considered where there were facts which suggested that an alternative specification might be more appropriate.

On the supply side there is a single behavioral relationship, that between the price of scrap and the quantity supplied. Holding all other variables constant this relationship traces out the usual supply curve. In Model II, the fact that a large portion of the quantity supplied is automatically recovered prompt material, suggests that the relationship between price and quantity may be non-linear. In the lower portions of the supply curve where quantities supplied can be assumed to come exclusively from prompt sources, one would expect price to have only a slight effect on the quantity supplied. Since this prompt material would get recycled at any price, the supply curve should rise very steeply in this region. Further out along the supply curve where marginal quantities are drawn from obsolete sources the supply curve may flatten out somewhat. Once scrap prices are high enough to make it economically feasible to recover obsolete scrap from the environment, relatively small price changes might bring large additional quantities of scrap into the market. It seems appropriate to at least allow for this possibility because there are presently large accumulations of scrap in the environment.

In order to allow for this potential non-linearity some equations were estimated using a logarithmic transformation of prices. The results were substantially worse than those obtained with a linear specification. However, such results cannot be taken as a positive refutation of the hypothesis just set forth or as proof that the price quantity relationship is uniformly linear along its entire range. If all of our observations happened to fall into the upper range of the supply curve, above the highly inelastic portion where only prompt scrap was recovered, then a linear specification would provide the best fit. The fact that prices have never dipped so low that no obsolete scrap was getting recovered tends to support the view that the industry has always been operating along this outer portion of the supply curve.

Of the other independent variables in the supply equation, linear specifications are most easily justified for exports and for Av_2, the proxy for availability of prompt scrap. For Av_2 this specification follows from the hypothesis that a change of a given magnitude in the level of productive activities that generate prompt scrap is passed back to steel mills, regardless of the absolute level of these production activities. For exports a linear specification follows from the hypothesis that each unit of scrap exported means one less unit of scrap to be made available to domestic consumers regardless of the absolute level of scrap exports.

The proxy for the availability of raw obsolete scrap, Av_1, presents a more difficult case. The functional form which correctly describes this relationship depends upon how quickly the more accessible sources of obsolete scrap become depleted as scrap prices rise. Unfortunately very little is known about this process. Obviously prices cannot climb indefinitely without some dampening of the depletion effect. There comes a point where all physically available scrap will have run out so that there is nothing left to be depleted. However, it is not clear that we were ever close to this point during the data period. The continuing build up of iron and steel scrap in the environment tends to suggest that we were not. Nor is it clear whether the relationship might not be approximately linear in the lower ranges before the scrap reservoir approaches exhaustion. Some regressions were run using a logarithmic transformation of the availability variable; however, these were inferior to regressions which made direct use of the proxy.

On the demand side there was little information to suggest what form the direct price effect should take. Two specifications were considered; a simple linear relationship between quantity and price, and a relationship between quantity and the log of price. The latter relationship was suggested by the nature of the residual alloy constraint on the use of scrap in steelmaking. It is possible that demand for scrap is relatively elastic at lower levels of scrap consumption where the residual alloy contaminants present in scrap are more than adequately diluted by large quantities of purer virgin materials. At higher scrap consumption levels, demand may suddenly become inelastic as steel producers begin to run up against constraints which specify maximum permissable levels of various alloy contaminants and are required to incur the costs of removing these alloy contaminants. Initially both specifications were tried. The results obtained with the logarithmic specification were highly unsatisfactory so that this formulation was abandoned.

There was also very little information available which might have suggested a specification for the cross-price relationship. We relied primarily on a linear specification. In addition a number of lag structures were tested in order to see if there might be time consuming adjustment processes involved. The best results were obtained with a six month distributed lag.

A linear relationship was specified between quantity demanded and steel production, the demand activity variable. This was based on the hypothesis that any given percentage increase in steel production, would cause an equal percentage increase in scrap consumption, holding scrap prices and pig iron prices constant. Our results were consistent with this hypothesis (estimated elasticity of demand with respect to steel production was close to 1.0).

Tables 8-4 through 8-6 presents the estimated supply and demand equations for scrap steel. All equations were estimated with two stage least squares using the serial correlation correction discussed in Chapter 10.

The best results were obtained with Model II, using total receipts of scrap as the dependent variable. In the estimated equations based on Model II most variables were highly significant and all coefficients had the expected signs. The magnitudes of the estimated coefficients seemed fairly reasonable in most cases.

Attempts to estimate equations based on Model I were much less encouraging. Numerous regressions were run using each of the separate obsolete scrap grades as the dependent variable. We experimented with a number of different data periods, and a number of combinations of independent variables. No equations were estimated in which more than two or three variables had the expected signs and t-ratios exceeding two. Even for these the magnitudes of the estimated coefficients were in most cases difficult to reconcile with some of the assumptions upon which the model was based. Such disappointing results were likely attributable to the very poor data which exists for separate grades of scrap.

The following discussion of results will pertain to those obtained using Model II (Table 8-6).

(1) Demand Activity Variable

Total raw steel production, TSTPRO, was used to indicate the level of activity in all scrap consuming processes. It had a positive sign, as expected and had a t-ratio of 11. The elasticity at the mean, 1.1, indicates that at higher levels of steel production, scrap and virgin

Table 8-3. ECONOMETRIC ESTIMATES FOR MODEL I

	Dependent variable	Independent variables					
		Constant	PHEVY1	TRND	TSTPRO	PPIG	SHREDEX
Supply							
(1)	SHRED	-360	+0.70 (1.7)	+3.6 (8.3)			
(2)	SHRED	-356	+0.64 (1.5)	+3.6 (8.4)			-0.02 (.40)
Demand							
(1)	SHRED	+32.1	+0.42 (.86)		+.0083 (2.6)		
(2)	SHRED	+603	-2.3 (3.2)		+0.1 (3.[illegible]	-4.6 (4.0)	

Note: All equations were estimated by two stage least squares using an autoregressive correction. T-ratios are in parentheses. Symbols are defined at end of Table.

Variables:

SHRED	Receipts of shredded scrap
PHEVY1	Price of #1 Heavy Melting scrap used as a proxy for the price of shredded scrap
TRND	Trend; proxy for increasing shredder capacity
TSTPRO	Total steel production
PPIG	Price of pig
SHREDEX	exports of shredded scrap

Table 8-4. ECONOMETRIC ESTIMATES FOR MODEL I-B

	Dependent variable	Independent variables					
		Constant	PBUN2	BUN2X	TRND	TSTPRO	PPIG
Supply							
(1),	BUN2R	-135	+6.8 (4.7)	-0.18 (1.3)			
(2),	BUN2R	-161	+7.5 (8.9)	-0.35 (3.4)	-1.3 (5.4)		
Demand							
(1),	BUN2R	-139.2	-4.4 (1.2)			+0.056 (2.9)	+4.4 (.88)
(2),	BUN2R	+159.6	-2.07 (.88)			+0.043 (3.6)	

Note: All equations were estimated by two stage least squares using an autoregressive correction. T-ratios are in parentheses. Symbols are defined at end of Table.

Variables:

BUN2R	Receipts of #2 Bundles
PBUN2	Price of #2 Bundles
BUN2X	Exports of #2 Bundles
TRND	Trend: to represent technological change in the scrap industry
TSTPRO	Total steel production
PPIG	Price of pig iron

Table 8-5. ECONOMETRIC ESTIMATES FOR MODEL II

	Dependent variable	Constant	Independent variables PSCRP	PROM	$PSCRP_{lag}$	TRND	TSTPRO	$PPIG_{lag}$	SCRPX
Supply									
(1)	TOTRS	-763	+52.9 (9.9)	+2.6 (4.9)	-10.2 (1.58)	+5.0 (5.6)			-.94 (6.9)
Demand									
(1)	TOTRS	+601.7	-23.5 (3.7)				+0.30 (11.0)	+9.66 (1.69)	
(2)	TOTRS	+1497.3	-22.2 (3.9)				+0.28 (1.27)		

Note: All equations were estimated by two state least squares using an autoregressive correction. t-ratios are in parentheses.

Variables:

TOTRS	Total receipts of scrap in thousands of short tons
PSCRP	Price of scrap deflated by BLS wholesale price index
SCRPX	Scrap exports in thousands of short tons
PROM	Proxy for availability of prompt scrap - the Federal Reserve Index of automobile production
$PSCRP_{lag}$	Proxy for availability of obsolete scrap - Almon lag on prices lagged one to four months
TRND	Trend; proxy for technological change in the scrap industry
TSTPRO	Total steel production in thousands of short tons
$PPIG_{lag}$	Price of pig iron deflated by BLS wholesale price index treated as Almon lag of five to eight months

materials continue to be consumed in almost the same proportions as at lower levels. Our estimate shows only a slight tendency for consumption of scrap to rise more than proportionately with steel production.

(2) Price of Scrap

The price of scrap, PSCRP, had an elasticity at the mean of 1.4. As we discussed in Chapter 7, interpretation of this parameter estimate raises some problems. Having used monthly data we cannot claim to have estimated a long-run elasticity. (Furthermore, we cannot be certain if this estimate is biased.) On the one hand the fact that adjustments in capital stock cannot be made from month to month suggests that our elasticity estimate may be biased downwards. On the other hand there is the possibility that several months of intensive scrap collection activity, occasioned by sustained high prices, would raise the costs of supplying scrap. Also there is the possibility that monthly changes in the quantity of scrap supplied are especially volatile because of speculative behavior on the part of scrap dealers. These last two factors would suggest that our estimates overstate the long-run elasticity.

In order to get a better estimate of the long-run price elasticity we can take advantage of the fact that we have included in the equation a proxy for the availability of raw scrap in the environment. Conveniently enough this proxy happens to be based upon lagged prices. Thus a lasting price change is felt in our equation not only as a change in present price but also as a change in the proxy variable. By plugging into the supply equation a postulated permanent one percent change one can compute an elasticity that takes account of some longer-run effects. We need merely sum the coefficient for present price (52.9) and the coefficient for lagged prices (-10.2). The revised elasticity which is computed from the sum of these coefficients is equal to 1.16.

Still it is open to question whether this new elasticity estimate is any closer to the true long-run elasticity. If, as we have implicitly assumed, the proxy $PSCRP_{lag}$ only captures the long-run effect of dwindling scrap availability our problem is not solved. In this case the revised elasticity estimate does not take account of the potentially offsetting effects of long-run capital stock adjustments and short-term inventory adjustments.

What is more likely to be the case is that our proxy variable captures each of the three adjustment effects at least to some extent. However, since we do not know whether four months is sufficient for all three effects to work themselves out completely it is still difficult to say with any confidence whether the revised estimate is higher or lower than the long-run elasticity. Our conjecture is that while four months of high prices is long enough for inventories to become run down, and for the availability of raw scrap in the environment to decline, it is probably shorter than the period of high prices which would be necessary both to convince scrap dealers to undertake capacity expansion and to allow these expansions to actually be completed.

One final factor must be kept in mind when interpreting our estimated price elasticity. An elasticity is a measure of the responsiveness of supply to changes in price in which both quantity and price changes are expressed in percentage terms. Thus, according to our estimate a one percent change in price will produce a 1.16 percent change in the quantity of total purchased scrap supplied (measurements taken at the mean).

Now recall that approximately half of the receipts of total purchased scrap consist of "automatically recovered" prompt scrap. We are not really interested in this half; rather we are interested only in the remainder which consists of obsolete scrap and a small amount of low quality prompt scrap. We have also maintained that changes in the total quantity of scrap supplied, which are produced by changes in the price of scrap, come mainly from obsolete and low quality prompt sources. If we make the strong assumption that the rate at which the automatically recovered prompt is supplied to mills is independent of scrap prices, then it must be that the change in quantity supplied following a one percent change in price comes entirely from obsolete and low quality prompt sources. While total receipts of scrap only increase by 1.16 percent the category obsolete and low quality prompt scrap will have experienced a 2.32 percent increase. Hence the short-run elasticity of the "product" obsolete and low quality prompt scrap would be twice the estimated elasticity which has been stated above.

It should be pointed out, however, that an elasticity of 2.32 is an upper limit. The elasticity of the "product" obsolete and low qualtity prompt scrap would only be this high if the quantity of automatically recovered scrap supplied did not respond at all to price changes. Otherwise the quantity of obsolete and low quality prompt supplied would be less than the change in the total quantity supplied. As we have previously mentioned however, short-run price changes are likely to affect the quantity of automatically recovered scrap supplied since scrap dealers can accumulate or draw down inventories in response to such price changes.

(3) Availability of Raw Obsolete Scrap

A four month Almon lag structure on scrap prices, $PSCRP_{lag}$, was used as a proxy for the accessibility of raw obsolete and raw low-quality prompt scrap. The choice of this proxy was based upon the hypothesis that high prices in the recent past would have encouraged intensive scrap collection activities which would leave the reservoir of raw scrap material relatively depleted; conversely, low prices would have permitted the reservoir to build up.

The estimated coefficient for $PSCRP_{lag}$ had the expected negative sign. However this variable turned out to be only marginally significant. The lag structure resembled an inverted "v," with low weights for recent prices, higher weights for two and three-month-old prices, and a low weight for the four-month-old price. We take this relatively poor showing as a reflection of the difficulties encountered in attempting to describe the size and quality of the scrap reservoir in terms of an index which can be used in econometric analysis. While it was argued above that lagged prices furnished the best proxy given the shortcomings of the existing data base, we readily admit that it is far from perfect. For instance it does not take explicit account of the rate at which materials enter the reservoir, the kinds of materials which enter the reservoir, or the location where materials enter.

(4) Scrap Exports

Scrap exports (SCRPX) had the expected negative sign and a t-ratio of about seven. The value of the coefficient, -.94, reassures us to some extent that the system of equations which we have estimated is properly specified. It will be remembered that one of the important simplifying assumptions upon which our model is based is that foreign demand is independent of domestic scrap prices. This assumption allows us to treat exports as an exogenous variable in the supply equation. Were th the assumption not true, exports would be determined simultaneously with shipments to domestic consumers (TOTRS), and prices (PSCRP), by a system of three equations; one for domestic demand, one for foreign demand, and one for total supply. An implication of this assumption is that each ton of scrap exported simply reduces by one ton the quantity of scrap which will be supplied to domestic consumers at any price level. That is, our estimated supply curve, based on quantity supplied to domestic consumers, should shift backwards parallel to itself by one unit for every unit of scrap which is exported. Since SCRPX and TOTRS are given in the same units, the coefficient for SCRPX should be in the neighborhood of -1.0. An estimated coefficient of -0.94 is reasonably close to this value.

(5) Technological Change

The trend variable, which was inserted to capture the effect of changes in technology which lowered the cost of supplying scrap, had the expected positive sign and had a t-ratio of 5.6. The elasticity, .12, indicates that changes in the costs of supplying scrap were barely noticeable on a month to month basis. Working with a period of 11 years the passage of a month represents a change of less than one percent in the variable TRND. An elasticity of .12 implies that holding all other factors constant, including price, the quantity of scrap supplied would increase by less than 1/10 of one percent from one month to the next, or by about one percent from one year to the next. These figures seem rather low indicating that perhaps technological change had a less pronounced impact upon the costs of supplying scrap than is often supposed.

On the other hand it is possible that the effect of some offsetting change, such as rising labor costs, is also picked up in the trend variable. No data was available on wages in the scrap sector so that we were not able to observe the effect of changing technology, while holding fixed all other factors which determine the costs of collecting and processing scrap. Because of the possibility that wages in this sector were rising faster than the general price level, the trend variable cannot be unambiguously interpreted.

(6) Availability of Prompt Scrap

The proxy for availability of high quality prompt scrap, PROM, had the anticipated positive sign and a t-ratio of about five. The elasticity, .2, seems low however, given that the relationship which is supposedly being represented is one between the level of activity in production processes that generate "automatically recovered" high quality scrap and the quantity total scrap receipts. Approximately 50 percent of receipts come from high quality sources. If the return of all high quality scrap were automatic, in the sense that it went directly from fabricating plants back to mills under long-term contracts, then one would expect a one percent increase in production rates of scrap generating activities to cause a one percent increase in the quantity of automatically recovered scrap. Since automatically recovered scrap is approximately 50 percent of total scrap receipts this implied a .5 percent increase in the quantity total scrap receipts and therefore an elasticity of.5.

There are two factors which might account for the difference between the estimated and the expected elasticities. The first has to do with the data. The proxy variable PROM was constructed from a number of Federal Reserve Indexes for sectors that were known to generate large quantities of prompt scrap; included were automotive production, production of appliances and air conditioners, production of transportation equipment, and production of industrial equipment. The amount of prompt scrap generated in activities other than these four is not known with any certainty. If for instance only half of all prompt scrap came from the four sectors represented in the proxy, and the rest was generated at a rate which was not correlated with activity in these sectors, one would expect an elasticity of only .25.

The second factor which might account for such a low estimate has to do with the nature of the relationship being modeled. As we described above in the variables section, some high quality prompt scrap is shipped to scrap dealers before returning to user mills. Because scrap dealers generally hold large inventories, the rate at which this material is generated and shipped to dealers may not be in phase with the rate at which it is shipped from scrap dealers to user mills. When dealing with short intervals of time on the order of one month, it is possible that a relatively constant flow of high quality prompt materials from scrap dealers to user mills might be maintained even though the flow of materials from fabricating plants to scrap dealers fluctuated widely from one month to the next. Such a pattern would result if scrap dealers were in the habit of accumulating inventory when larger than average quantities of prompt material generated, and drawing down inventories when the generation of prompt scrap was unusually low. Behavior of this type would tend to dampen the impact that short-run variations in the rate at which prompt scrap was generated had upon the rate at which prompt scrap was supplied to mills, and hence to explain the low estimated elasticity.

(7) Price of Scrap - Demand

The price of scrap, PSCRP, had a negative coefficient, thereby giving the expected downward sloping demand curve. The price elasticity at the mean was .63.

As was the case on the supply side the estimated price elasticity must be interpreted with some care. It is based upon short-run responses to monthly price changes and therefore may differ from the long-run elasticity. In the short-run steel furnace capacity is fixed so that the choice of input mix is somewhat more constrained than in the long-run. In particular, the quantity of scrap which can be used may be limited in the short-run by the relatively inflexible input requirements of the BOF. A permanent change in relative input prices could, however, induce an expansion of electric furnace capacity thereby increasing opportunities for scrap consumption. (Hence it is likely that .63 underestimates the long-run price elasticity at least in the vicinity of present scrap consumption levels).

Another problem with our estimate is that while it may be reasonably accurate for short-run price movements over the range into which our observations fall, (there is a possibility that the demand curve drops off quite sharply somewhere beyond this range). The reason for this is that once residual alloy limitations are reached it may be impossible to vary input mixes any further in favor of more scrap without exceeding these limitations.

(8) Price of Pig Iron

Using its present price as an indicator of the cost of pig iron, no significant cross price effect was found. Using a six month distributed lag on pig iron prices some marginally significant results were obtained. The cross price elasticity computed at the mean was .28 with a t-ratio value of 1.69.

This estimate is open to a number of criticisms. First of all, as we noted above in the variables section, there is reason to doubt that reported pig iron prices accurately reflect the marginal cost of pig iron to integrated steel makers, or even the cost of pig iron to purchasers of merchant pig on the open market. Second, the reason why scrap demand should respond immediately to changes in the price of scrap, but slowly to changes in the price of pig iron, is not at all apparent. Therefore it is open to question whether or not the observed relationship between scrap purchases and pig iron prices was a result of pure chance.

IV. ESTIMATION OF TAX IMPACTS

The models developed in the previous section can be used to derive estimates of the impact that the preferential taxation of virgin iron ore, coal and limestone production had on the quantities of steel recycled. Basically we have two alternatives in developing these estimates. One is to use the estimated demand curve and its cross elasticities as representative of the substitutability of scrap for virgin-based inputs. The second is to assume (1) long-run substitutability between virgin and scrap inputs is perfect, and (2) the long-run supply of virgin inputs to steel production is elastic, and base the recycling estimates on the supply curve for scrap steel products.

In the first approach, which is properly termed a short-run viewpoint, we use the estimated elasticity of the demand for scrap steel with respect to the price of pig iron to derive the impact of the preferential taxation of virgin iron, coal and limestone production on the demand for scrap steel inputs. This elasticity was estimated as .28, subject to the qualifications noted earlier. In Chapter 6 we estimated the impact of the tax subsidization of virgin steel input production at at most three percent of the price of pig iron. This indicates the demand curve for scrap steel might rise by .28 x 3% = .84% should the tax subsidies be eliminated. A shift in demand of this magnitude would increase the price of scrap steel by $.84[Ed/(Ed + Es)] = .84[.63/(.63 + 2.32)] = .18\%$, where Ed and Es refer to the elasticities of demand and supply respectively. The quantity of obsolete scrap steel recycled would increase by the change in price multiplied by the supply elasticity, or .18 x 2.32 = .42%.

In the second approach, which is properly termed an optimistic long-run assessment, we need only multiply our estimate of the long-run supply elasticity by the change in the price of virgin-based inputs to derive the upper limit on the quantities of obsolete scrap steel which would be recycled should the tax subsidization of the inputs to pig iron production be eliminated. This estimate of 2.32 x 3% = 6.4% is biased upwards, not only because of the computations underlying the figure of a three percent tax impact on price, but also because of the assumption of long-run substitutability of scrap steel for pig iron. Residual alloy contamination, though remediable at the cost of slowing the steel making process, makes scrap steel a less desirable input and even in the long-run will limit the substitutability of the two inputs.

CHAPTER 8
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CHAPTER 9

PAPER

The paper industry utilizes virgin wood pulp and recycled scrap paper to produce a wide variety of products for final consumption. The fraction of all paper products eventually recycled has been declining irregularly for the past 25 years. In 1950 approximately 28 percent of all paper products were recycled, but by 1973 the recovery ratio had fallen to 17 percent.[1] In addition, the market for wastepaper is characterized by violent price swings. For example, within a recent twelve month period the dealers' price ranged from $43 to $4 per ton.

This chapter investigates the flow of materials through the paper industry and the nature of competition between primary and scrap materials as inputs to the paper industry. An econometric model of the wastepaper industry is specified and estimated, and, finally, we compute the impacts of the preferential taxation of the forest products industry on incentives to recycle wastepaper.

I. INPUTS TO THE WASTEPAPER INDUSTRY

Raw material inputs to the wastepaper industry originate during the fabrication of paper products and after paper products are used by consumers. The first category of inputs is termed "pre-consumer," "industrial," or "prompt" scrap. The latter category of inputs is normally termed "post-consumer," or "obsolete" scrap. Industrial scrap is generated in converting or fabricating operations which produce intermediate or final paper products from paper or paperboard. Post-consumer wastepaper is that discarded by commercial, institutional, and residential consumers of paper and paperboard products.

A. Industrial Scrap

Depending on the fabrication stage, material from industrial sources may be almost identical to that coming off paper and paper board machines. In integrated mills, this material is routinely recovered and processed for blending with virgin wood pulp. In most cases this material requires only collection, aggregation and transportation to user mills. However, in some operations, industrial wastepaper will be combined with coatings or adhesives which will require additional processing before the fiber is acceptable as a production input. This processing is not performed by the wastepaper industry as defined here, but by the user mills.

The major advantages of industrial sources are large volumes of homogeneous residual materials, their low or at least predetermined levels of contamination, their proximity to users, and disposal practices which preserve the economic usefulness of the material.

While it is generally assumed or calculated that perhaps 85 percent to 90 percent of industrial wastepaper is recycled, this figure does not apply equally to all product lines because of differences in concentration of sites, contamination, and homogeneity of discard streams.

The distribution stage, between fabrication and use, contributes a portion of the industry's resource base which shares characteristics of prompt and post-user wastes. This category of residuals generation includes over-issues of the printing and publishing sector, and inventories of obsolete paper products. Materials from this stage are usually homogeneous, and contamination may not be significantly different from that found at the converting stage. However, low average size of discard streams and more numerous and scattered sites may not permit low cost recovery of separate raw materials.

B. Post-Consumer Scrap

The post consumer source of wastepaper generates by far the greatest volume of material, and availability does not appear to be a constraint upon increased recovery. However, due to lower concentrations of generating sites, less homogeneous flows and higher levels of more intractable contamination, recovery is more costly and materials are generally of lower value.

The post-consumer source includes several sub-classes of generating site: commercial, institutional, and residential. The types of material residuals, the volume and homogeneity of discard streams, and the types and levels of contaminants are quite distinct between the two classes. Commercial and residential generators are different also in degree of site concentration and internal housekeeping practices which may affect the feasibility of recovery.

Banks, office buildings and retail outlets generate high volumes of relatively homogeneous wastepaper, often of high quality paper products low in contaminants. This permits economical segregation of materials at the generating site, compacting for ease of storage and handling, and high density collection activities. Furthermore, on-site preparation of some materials, e.g., corrugated containers, is often not significantly more costly than for disposal.

Residential waste materials are more often mixed, heavily contaminated in use, and require more handling services per unit recovered. One exception to this appears to be newspaper, which may be more difficult to discard regularly in combination with other refuse than to accumulate and discard separately.

II. DEMAND FOR WASTEPAPER

This section reviews the various production processes which use wastepaper as an input and factors influencing the substitutability of secondary for virgin fiber. Strength and cleanliness or brightness requirements in end-use applications appear to have the greatest impact on the acceptability of paperstock fiber. The use of high speed forming machines turning out standardized products may also impose strength and contamination requirements which adversely affect the use of paperstock. Certain product characteristics imparted by the forming machines predominantly used in the industrial sector utilizing paperstock may put these products at a technical disadvantage in some uses. Finally, since 1945, most new productive capacity has been built near sources of virgin pulp inputs imposing a transportation barrier to the use of more secondary fiber, at least in the short-run.

The demand for paperstock (graded wastepaper) as a raw material input is derived from demand for the outputs it is used to produce. These outputs may be intermediate producers' goods or final consumer goods. Paperstock provides about twenty-two percent of the fiber used in the manufacture of paper and paper board. Neither its use nor its importance relative to other fiber sources is distributed evenly across all production categories.

The demand for paperstock is in fact an aggregation of demands for different paperstock grades, derived from the requirements of various production processes. Different product lines require different mixes or blends of paperstock fiber, used alone or in combination with virgin wood pulp fibers. Conversely, the use of specific paperstock grades may be concentrated in a few distinct product lines for which the given grade provides the appropriate fiber characteristics. Since product lines within the paper and paperboard industries vary widely in end-use applications, this means that the market conditions for some paperstock grades will be quite different from those of other grades.

Paperstock is a source of cellulose fiber of various types, and thus competes with other fiber sources - principally virgin wood pulp. Paperstock fiber competes with virgin fiber in the input market as a substitute raw material. In intermediate and final goods markets products made from paperstock fiber compete with those based on virgin fiber.

Paperboard production accounts for approximately 75 percent of all paperstock consumed.[2] Materials are drawn from both industrial and post consumer sources. Boxboard accounts for by far the largest portion of paperstock used in paperboard production, although corrugating medium is also an important consumer of paperstock, both in terms of current levels and potential for growth. The paperboard sector has experienced a high growth rate over the last two decades, mostly in linerboard output which has grown at an average annual rate in excess of 5.5 percent.[3] The other growth component of the sector has been special foodboard, a solid virgin fiber product, which has displaced paperstock-based (combination) boxboard from a substantial share of the growing market for food packaging. These two product lines use very little paperstock, accounting for the declining relative importance of paperstock fiber in the paperboard sector and in the industry as a whole.

The historical trend in paperboard categories using paperstock is suggested in the figures below:

Table 9-1

	Percent total fiber from paper stock	
	1961	1971
Boxboard	83.4	64.8
Linerboard	11.7	2.2
Corrugating medium	21.5	19.1

Source: Secondary Fiber Recovery Incentive Analysis, Resources Planning Institute.

Combination (secondary fiber) boxboard is made entirely from paperstock inputs and includes all grades of paperstock. It is formed in layers on multiple-cylinder machines; previously market wood pulp was used for the outer laminations, but high grade paperstock has replaced wood pulp in this use. The cylinder machines impart fiber alignment in the direction of cylinder rotation; this reduces tear strength in the machine direction. Kraft boxboard is produced on Fourdrinier machines which reduce the fiber alignment.[4] The importance of this difference in establishing market shares is difficult to determine. While combination boxboard could presumably be produced on Fourdrinier machines, little experimentation has been conducted in this area.

Plants incorporating cylinder machines and using paperstock were formerly used by the virgin-based sector drawing upon forest of the Northeast regions. They are located near urban populations which generate the necessary paperstock supplies. Fourdrinier capacity is located near to the more recently (post World War II) exploited virgin resource base in the South and Northwest, remote from paperstock sources. These machines are of large capacity compared with cylinder operations, and run continuously at high speeds producing standardized products.

Corrugating medium is the second most important consumer of paperstock, and the one area in which paperstock inputs may grow in relative importance. Corrugating medium is produced by Kraft, semi-chemical (NSSC), and recycling processes. The last of these uses a 100 percent paperstock input, primarily corrugated obtained from both prompt and post-user sources. The semi-chemical process, which involves chemical pre-treatment of the bulk wood and mechanical separation of fiber, uses primarily hardwood stock which has shorter fiber than the softwoods which predominate in the Kraft process. The semi-chemical process routinely includes corrugated as a fiber supplement. After repulping, the softwood fibers which predominate in corrugated materials still compare favorably with the shorter hardwood fibers. Recycled fiber used exclusively or in combination with virgin fibers provides technical advantages in performance on the corrugating machine, and end-to-end strength.

Linerboard, the major growth product in the paperboard sector, uses negligible amounts of paperstock, and that used is industrial scrap obtained from integrated converting operations. Recycled linerboard from cylinder machines appears to be at a technical disadvantage in competition with Kraft liner with respect to burst strength, which is a function of fiber length and the forming process. The disadvantage is greatest in the lower calipers (thicknesses); compensation may require up to 25 percent more fiber by weight, resulting in production cost and use disadvantages. The burst strength parameter is specified in a code of standards for shipping containers, and manufacturer's adherence to such standards affects liability in cases of loss in transit. Whether the specified parameter value is related to product performance is unclear.

In the paper sector of the industry, paperstock is used in products which rely on pulp fiber types similar in most technical features to paperstock fiber.[5] Both groundwood (mechanical fiber separation) pulp and semi-chemical hardwood pulps produce short fiber length and contain various wood substances which are removed in the full chemical pulping processes. Paper products consume approximately 16 percent of all paperstock supplied. Most of this is high grade industrial paperstock, much of it acquired through self-developed, captive converter sources. An important exception is recycled newsprint, which uses post-consumer newspapers.

Printing and writing paper, including newsprint, consumed approximately seven percent of all paperstock, from which six percent of total fiber requirements were obtained. Within this group, recycled newsprint uses almost all post-consumer scrap. The remainder of paperstock consumed goes primarily to tissue and sanitary papers, where in recent years it has provided 25 percent to 30 percent of the total fiber requirements.

Recycled newsprint appears to be equal or superior to virgin newsprint in all technical characteristics, and can be marketed profitably at a 10 percent discount form the virgin price. Over two-thirds of the newsprint consumed in this country is imported from Canada; much of this is obtained from subsidiaries of U.S. newspaper publishing firms.

The remaining sector of the paper and paperboard industry is construction paper and board. Within this sector only construction paper employs paperstock, which provides about 70 percent of fiber requirements. This category consumes about nine percent of total paperstock.

Technological and organizational developments in the paper and paperboard industry over the last forty years have restricted the range of substitutability between secondary and virgin fiber. Industry growth has been dominated by large firms, vertically integrated from timber owning and harvesting through pulp manufacture, paper and paperboard production and often into final product fabrication. Pulp mills in combination with paper and paperboard machines represent a very capital intensive production process, located near sources of virgin fiber and remote from paperstock sources. The introduction and development of the Kraft pulping process has permitted pulping of a greater variety of wood species and use of primary wood processing residues, thus lowering costs of virgin material use. Chemical by-products of the process have rendered virgin-based production even more attractive.

Mills which rely wholly or in part on paperstock fiber usually employ older, low capacity cylinder machines once used by the virgin-based paper and board industry drawing upon the forest resources of the Northeast and Northcentral regions. Product characteristics imparted by these machines are often alleged to be the cause of the deteriorating position of paperstock relative to virgin fiber, particularly in the major industry growth sector, linerboard.

Presently about 80 percent of paper and paperboard capacity is not equipped to handle paperstock. Mills using paperstock may employ special de-inking equipment, or special pulping facilities designed to disperse the more intractable contaminants. New paperstock re-pulping technology has been developed in Europe and Japan, but has not been introduced to any large extent in the United States.

Possibly of greater significance is the availability of paper and paperboard forming machines which are capable of accepting a greater variety of paperstock fiber, operating at higher speeds and imparting fewer undesirable characteristics than do the cylinder machines. Again, little of this type of capacity has been brought on line in this country.

Since expanded use of paperstock appears partly contingent upon mix and location of the industry's capital stock, adjustments to changes in relative fiber prices or availability conditions may require many years.

III. ECONOMETRIC SPECIFICATION AND ESTIMATION

A. Specification

The quantity of paperstock demanded as an input to the production of paper and paperboard is hypothesized to depend upon:

1) Price of paperstock
2) Price of market wood pulp, the principal substitute fiber source
3) The level of activity in the sectors of the paper and paperboard industry using paperstock as an input
4) Prices of other inputs to the production of paper and paperboard
5) Characteristics of the capital stock in the paper and paperboard industry affecting the ease and extent of substitution between secondary and virgin fiber

It was hypothesized that the quantity of paperstock supplied in any period would depend upon the following:

1) Price of paperstock
2) The availability and accessibility of raw materials required as inputs to the wastepaper industry
3) Prices of other inputs to collection, processing and storage activities of the wastepaper industry
4) Characteristics of the capital stock used in the supply process.

The following section discusses the effects these variables are expected to capture, the empirical measures used, and the form in which the variables are included in the estimated equations. A later section will present the estimation results and their interpretation, and discuss assorted problems related to the estimation of parameters and the inferences to be drawn from them.

(1) Quantity of Paperstock

Modeling the wastepaper market in an empirically testable form is complicated by the fact that supplies of scrap are derived from two sources, industrial and post-consumer, and the parameters which affect supplies from these two sources are different.

The empirical measure used for the quantity of paperstock is taken from the monthly Current Industrial Reports, Series M 26 A, published by the Department of Commerce. The reported figures are for raw tonnage of paperstock consumed at user mills, all grades combined. These figures exclude some industrial wastepaper which is transferred internally in plants which combine paper or paperboard manufacturing with converting operations. However, the measure includes that portion of industrial wastepaper supplied by sources external to the user firms.

A series on inventories of paperstock at user mills is also available from the same source, permitting adjustment of consumption figures to receipts of paperstock. Receipts of paperstock are calculated to be equal to consumption plus the month to month change in reported inventories.

(2) Price of Paperstock

The price of paperstock is included in both the supply and demand equations. In keeping with the level of aggregation of the model, we used a composite price for paperstock of all grades as reported by the Bureau of Labor Statistics in "Wholesale Prices and Price Indexes". The price is based on weekly quotations for the separate grades in four regional markets.

Prices are brokers' buying prices for large quantities, f.o.b. dealers' yards. Thus these prices are not the prices paid by user mills, which would include transportation charges from dealers' yards to mill sites, and brokers' profit. The price series is not totally satisfactory as a measure either of the price received by the suppliers of paperstock, or of that paid by users. Other prices used in the model are delivered prices. The omission of transportation charges from the price of paperstock can introduce specification errors in the tested model, with resulting bias in the estimated results. This problem will be considered in the section reporting the econometric results.

(3) Price of Woodpulp

Within the range of technical substitution possibilities available to them, the operators of an existing mill choose between paperstock and virgin wood pulp in determining their fiber source mix. The price of wood pulp is included in the demand equation to reflect these substitution possibilities and to obtain an estimate of the cross-elasticity of demand for paperstock with respect to the cost of obtaining wood pulp.

The wood pulp price applies only to market wood pulp, approximately 10 to 15 percent of pulp production. The price measure used (from BLS, "Wholesale Prices and Price Indexes") is a composite of prices for a number of wood pulp grades. Most of the marketed pulp for which prices are reported goes to the production of paper or types of paperboard in which only small amounts of paperstock are regularly used. Major paperstock consumers use small amounts of wood pulp, and much of this is probably low grade pulps and screening for which market prices are not reported, or not included in the composite price index. In addition, the groundwood price did not change over the period for which the models are tested; yet, this type of pulp is one for which paperstock provides a fairly close substitute.

The goundwood price component represents an extreme case of a more general problem with the reported prices of woodpulp: very little variation in the reported prices occurs for the period studied. These prices may be viewed as posted or list prices set by the oligopolistic pulp-producing sector of the paper and paperboard industry. This price is often discounted when pulp production exceeds requirements at integrated mills and surpluses are placed on the market. In times of shortage, actual selling prices may be marked up considerably, or available pulp rationed to customers. Thus, the reported price is not altogether a satisfactory indicator of the cost of obtaining wood pulp.

Several possible methods of dealing with this difficulty were considered. The first approach involved replacing the reported price of wood pulp with proxies representing pulp scarcity conditions more accurately. These proxies included wood pulp capacity utilization, the ratio of pulp production to total paper and paperboard production, and the ratio of pulp inventories to pulp shipments. These proxies would of course represent ordinal changes in the cost of obtaining wood pulp, and cannot easily be related to cardinal values which are required to compute meaningful cross-elasticities of demand.

The second approach involved replacing the reported price of wood pulp with prices which would reflect more accurately the actual price at which pulp could be acquired in the market. Possible replacements included the price of pulpwood, the principal raw material input to the production of wood pulp, on the grounds that this price was generated in a more competitive market and that scarcity conditions for wood pulp would parallel those for pulpwood. There is no monthly price series for pulpwood. The annual series of pulpwood prices suffers from discontinuities, as well as incomplete coverage of pulpwood species, regional markets and types of purchase arrangements.

The relationship between pulpwood prices (stumpage or delivered cords) and the price at which customers acquire pulp is clouded by industry structure, the increasingly heavy use of residues in pulp production, and the existence of large pulpwood inventories.

An alternative surrogate for the price of wood pulp is the price of the Pulp Substitute category of paperstock. Since this material is a close substitute for wood pulp, actual market prices for the two should be in equilibrium, separated by a constant processing cost differential. Since much of the pulp substitute paperstock is acquired through non-market channels, its price may share some of the shortcomings noted for the price of wood pulp. The pulp substitute price does display less variation over time than those of the bulk grades. An equation was estimated using this replacement for wood pulp price. Discussion of the substitution and related adjustments in other variables is contained in the section on econometric results.

(4) Activity in Paperstock Consuming Sectors

Two sectors, combination paperboard and construction paper, consume by far the major proportion of the bulk grades (news, corrugated, mixed) handled by the wastepaper industry. With the exception of recycled newsprint, most of the paperstock used in paper production is industrial, obtained from converter plants under long term contractual arrangements. Some corrugated, again mostly industrial in origin, is routinely used in semi-chemical corrugated production. Together, combination paperboard and construction paper use almost 85 percent of paperstock consumed.

A monthly series for construction paper and board output is available from the Department of Commerce "Current Industrial Reports," Series M 26 A. Regrettably, a monthly series for combination paperboard is reported beginning only in 1968. It was thus necessary to construct a comparable series for the years 1960 to 1967.

Annual data in the American Paper Institute's "Statistics of Paper and Paperboard" have been reclassified to conform with the combination paperboard reporting category introduced by the Census in 1968. The construction of a monthly series for combination paperboard relied upon the API annual percentage distributions of certain paperboard categories between combination and virgin-based paperboard.

The monthly combination paperboard series was constructed by adding together the monthly series for folding boxboard, set-up boxboard, container chip and filler board. To this was added a percentage of corrugated container and linerboard outputs, using the annual percentage distributions in the annual reclassified data series. Special foodboard was excluded from the combination paperboard category. This series was tested for internal consistency, and the results indicated that the reported and constructed series measured the same quantity. A discussion of this testing procedure follows.

Construction of the combination paperboard series, test for consistency

The measure of activity in the combination paperboard sector was constructed by splicing the monthly series for this category reported in the Department of Commerce "Current Industrial Reports" for the period January 1968 to August 1974 with a series compiled from reports for sub-categories from January 1961 to December 1967, from the same publication. The sub-categories have been listed in the earlier discussion of this variable. The categories to be included were checked with Census bureau personnel in charge of the reclassification and with the chief economist for the American Paper Institute, Dr. Benjamin Slatin.

This series was tested for internal consistency in the following way: Two new variables were defined, one taking the values for the combination paperboard series (compiled) from January 1960 to December 1967 and the value zero from January 1968 to August 1974; the other was assigned the value zero from January 1960 to December 1967, and the (reported) values for combination paperboard from January 1968 to August 1974. Both variables were used together to replace the single (constructed plus reported) series for combination paperboard in the demand equation. Estimation of this demand equation produced coefficients and t-statistics for each of the new variables very close to those obtained in the equation estimated using the single (constructed plus reported) combination paperboard series. The coefficients and t-statistics for the remaining variables remained the same for both equations. Comparison of the estimated results is displayed below:

CMBPBD (Combination paperboard series January 1960 to August 1974)
Coefficient: 1.109
t-statistic: 13.298

CMBL (January 1960 to December 1967) = 0
(January 1968 to August 1974) = CMBPBD
Coefficient: 1.15
t-statistic: 13.742

CMBL (January 1961 to December 1967) = COMBPBD
(January 1968 to August 1974) = 0
Coefficient: 1.21
t-statistic: 13.459

(5) Availability and Accessibility

(a) Industrial scrap The availability effect refers to the impact that variations in amounts of material physically available can have upon the market supply of paperstock. The component of the paperstock supply derived from industrial sources is that most likely to be affected by material availability.

Generators of prompt wastepaper provide fairly high volume, homogeneous material flows which suggests a relatively brief turnaround time from generator to user since aggregation and processing requirements are low. Usually these materials are acquired through long-term arrangements with "captive" suppliers. Thus there is a component of the measured industry supply flow which is quickly, routinely and completely recovered - within the established supply network - and which is likely to be influenced by the amounts of material available for recovery, rather than by industry response to price incentives.

Accurate specification of the supply relationship, where the dependent variable does include a significant component from this source, should include an indicator of raw material availability. This material is generated at the converting or fabricating end of the production sequence; thus, an indicator of activity at this stage should be included in the supply equation. Direct measures of the amounts generated, or calculation of the percent of material throughput generated as wastepaper over time are not available.

There remain the questions of which empirical measure to employ, and how the time-form of its relation to the dependent variable should be specified. As a measure of the availability of the prompt paperstock component we have used the Federal Reserve Index of production at the converting stage for paperboard containers and converted paper products. The index used, IPBP, is a simple average of the indexes for these two sectors. Other factors held constant, an increase in measured activity an increase in measured activity at this stage is expected to have a positive influence on the quantity supplied. The supply relationship to be empirically tested must specify when this impact on supply is to occur, relative to the time at which the material is generated.

It is reasonable to expect that any current effect on industry supply activity is the result of an earlier change in material availability.

If the data periods are lengthy relative to the turnaround time for prompt scrap (e.g. annual), same period levels of activity in the prompt-generating production stage would be appropriate. If the data periods are brief relative to turnaround time, (e.g. monthly),activity variables should be lagged the appropriate number of time periods from that in which the effects of changes in activity are to be realized. The lags specified in the estimated equations are fixed, one month lags.

Since the time interval between production of paper and paperboard and the fabricating of paper products which generates prompt scrap may be quite short, it is conceivable that indicators of activity in the prompt-generating operations will be closely associated with indicators or measures of activity in the consuming sectors. This opens the possibility that independent explanatory variables in the demand equation will be duplicated in the supply equation. However, a model tested with monthly data and specifying a time-lagged relationship between availability and impact on supply would permit more effective separation of the supply and demand relationships.

The inability to separate effectively the supply and demand specifications in the model which was estimated with annual data may be a principle reason for the unsatisfactory results which were abtained.

The use of a fixed period lag between the occurrence of generating activity and the hypothesized effect on the industry supply curve assumes that the time relationship is invariant. However, some slack may be introduced into this otherwise taut sequence by speculative behavior on the part of dealers and brokers. If speculators feel that prices for outputs derived from prompt materials are likely to move upwards in the near future, they may hold supplies off the market in anticipation of these higher prices. If they anticipate that prices are likely to decline, leaving them with bulky perishable inventories of lower value, they may attempt to unload quantities at a higher rate than otherwise. This type of behavior will alter the time relationship between the indicator of availability and the supply shift effect of changes in availability.

(b) Post-consumer scrap The earlier general discussion of supply suggested that availability of obsolete or post-consumer wastes was far less likely to operate as a shifter of supply than in the case of industrial scrap. In general, the physical amounts of post-consumer wastes are very large in comparison with the amounts recovered. Characteristics of post-user wastes other than simply the amounts of material discarded must have some bearing on the amounts and mix of materials recovered from this source. These other characteristics are grouped under the term "accessibility" and include the spatial and size distribution of materials deposits or generating sites, and the composition of waste streams or reservoirs. Changes in these characteristics from period to period may be expected to have an effect upon the costs to the industry of obtaining suitable inputs, and thus have an impact upon the industry's supply of outputs. Although the notion of a reservoir stock of discarded products and production residuals awaiting collection and processing appears less appropriate for the wastepaper industry than for the less perishable ferrous and non-ferrous scrap materials, it still may be desirable to account for this effect in the supply equation for paperstock.

While changes in the characteristics of the wastepaper resource base, in particular the post-user component, cannot be measured directly, it is possible to relate industry activity to changes in these characteristics.

Assuming that the wastepaper industry behaves rationally and exploits the most accessible sources of inputs first, high levels of recovery acrivity in one period could temporarily shift the industry supply curve upward to the left in succeeding periods as a result of decreased accessibility of materials remaining in the resource base. Although there is no relatively long-lived stock of discarded wastepaper awaiting collection in more or less disadvantageous locations or conditions, there are a number of junctures in the supply process where inventories of discarded materials may be accumulated, and depletion at these holding points could temporarily disrupt the regular flow of wastepaper inputs to dealers, or require greater collection and processing costs to maintain a given flow of paperstock in later periods. Moreover, dealers' and brokers' inventories of graded scrap outputs or materials in process could become depleted in periods of intensive supply activity, resulting in or contributing to a temporary backward shift of the supply curve.

To reflect this effect, a variable incorporating a lag structure imposed on past prices of paperstock (period t-1 to t-4) is included in the supply equation. The expected sign for this variable is negative, indicating that high recovery efforts in the past, represented by high past prices for industry outputs will lead to higher recovery costs and a backward shift in supply for some number of succeeding periods.

This proxy variable of course does not measure directly the changes in the concentration or homogeneity of waste flows tapped by industry efforts. Such changes can shift the accessibility gradient presumed to be exploited rationally by the industry. This means, for example, that seasonal alterations in concentration or homogeneity might disturb the expected relationship between lagged prices and current supply.

(6) Other Variables

The cost of certain inputs to the process of supplying wastepaper was proxied by a data series on the wages of sanitary workers. This variable proved insignificant in all specifications. An additional cost of using wastepaper is the cost of transporting the material to the user facilities. Accordingly we included a series on railroad freight rates in the demand equation. It too proved insignificant in all specifications. No variables were found which would represent an index of the capital stock of the users or suppliers of paperstock.

B. Econometric Estimation

Before presenting the econometric estimates of supply and demand, we will devote a few paragraphs to considerations underlying our choice of period for the analysis and the frequency of observations.

Short-run adjustments in the wastepaper industry take place rapidly, so that many of the behavioral relationships being modeled occur within a period of months. As a result, the use of annual or even quarterly data entails considerable loss of information on the adjustment mechanisms and their timing. On the other hand a distributed lag model using annual data would be required to capture the long-run effect of changes in relative prices on investment decisions in the industry. Ultimately, data availability restricted our observation interval to one month. Data on many of the important variables were available for periods of fifteen years or less, effectively precluding the estimation of a distributed lag model using annual data. A side benefit from the use of monthly data is that it permits the separation of industry activity variables and availability of raw materials in the specification of supply and demand. The relationship between the results obtained with monthly data and the longer-run adjustments of interest for policy purposes will be discussed following the presentation of econometric results.

The monthly data we obtained were not seasonally adjusted. Although seasonal adjustments are made routinely for many monthly time series, our data had not been adjusted. Before we proceeded to perform these adjustments, we deemed it prudent to examine further whether, in fact, such adjustments were desirable. The use of non-seasonally adjusted data relies upon the assumption that the specified equation is equally applicable to all observations.

The demand equation, in particular, includes a number of variables affecting the use of paperstock, all of which could include a common seasonal element. Examination of the production figures for the major paperstock consuming sectors indicates a seasonal slackening of activity in the summer months.

The appropriate hypothesis to test is whether the intercept for an estimated demand relation incorporating a seasonal dummy variable is significantly different from the intercept of an equation estimated without a seasonal dummy variable (see Johnston, p. 179).[6] The dummy variable for the demand equation was defined to have the value one for the month of July in each year, and the value zero for all other months. The statistical comparison indicated there was not a significant difference, therefore, the use of non-seasonally adjusted data appears to be appropriate.

Estimated supply and demand equations for two models of the wastepaper industry are presented in Table 9-2. In the first model the dependent variable for both supply and demand was the consumption of paperstock, whereas receipts of paperstock, which equal consumption plus changes in inventories, were used as the dependent variable in the supply equation of the second model. In the second model demand is disaggregated into two components, consumption and changes in inventory holdings. The cunsumption equation is identical with that reported in the first model. We were unable to estimate a satisfactory inventory adjustment equation, and consequently have not reported one as part of the second model. The equations were specified as linear and additive in the independent variables and were estimated by two stage least squares.

(1) Demand

All variables have the expected sign in the demand equation. With the exception of the price of wood pulp, coefficients are significant at the 0.01 level; for price of wood pulp, coefficients are significant at the 0.05 level.* The less favorable t-statistic for this variable may be related to the unsatisfactory nature of the data series.

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* See Chapter 10 for a more thorough statement of statistical significance under two stage least squares.

Table 9-2
SUPPLY AND DEMAND FOR WASTEPAPER
(January 1961 to December 1972)

Variable	Constant	PP	PWP	QPBD	QCP	IPBP	L
Model I							
demand (consumption)	49.1	-.13 (2.37)	+.11 (1.94)	+.51 (6.20)	+1.11 (13.30)		
Supply (consumption)	457.7	+.46 (10.62				+.31 (3.03)	-.40
Model II							
Demand*							
Supply (purchases)	450.0	+.40 (8.89)				+.32 (2.25)	-.34

* Identical to Model I.

Variables:

P	The BLS index of paperstock prices, divided by the BLS wholesale price index (times 1,000)
PWP	Composite wholesale price index of woodpulp divided by BLS wholesale price index (times 1,000)
QPBD	Production of construction paperboard in thousands of tons
QCP	Production of combination paperboard in thousands of tons
IPBP	Federal Reserve Index production of converted paper products and paperboard contains production (times 10)
L	An Almon lag on one through four month old prices of paperstock (t-ratios in parentheses)

Dependent Variable: Consumption or purchases of paperstock in thousands of tons

The estimated coefficients appear to be of the correct magnitude, where independent information permits comparison. Information on construction paper and board and on combination paperboard, regarding the percentage of fiber content obtained from paperstock and the percent of total paperstock consumed by these sectors is available from a cross-section industry survey conducted by McClenahan for the two-year period 1969-70.[7] According to the survey, approximately twelve percent of paperstock consumed is used in construction paper, where it accounts for two-thirds of production, by weight. Since the measure of activity in this sector included output of construction board which uses no paperstock, the coefficient should be less than two-thirds. The estimated coefficient (0.51) conforms with this expectation. The significance assigned to this coefficient lends weight to the opinion of numerous industry observers that the fortunes of the paperstock market are closely related to movements in the construction industry. This would of course be more relevant to the market situation for the bulk grades than for the high grades which are not used in this sector.

The McClenahan cross-section survey indicated that approximately 1.15 tons of paperstock is required for each ton of combination boxboard produced - the result of weight losses during processing. Combination boxboard is by far the major component of the combination paperboard sector whose activity is measured by QCP. This estimated coefficient of 1.11 is compatible with this information.

The calculated elasticity for paperstock demand with respect to its own price is 0.16. This result also is not unexpected, given the characteristic division of users and non-users of paperstock, particularly in terms of large-scale use. Substitution of paperstock for pulp fiber may indeed occur to a significant extent, as it did in the replacement of virgin fiber with high grade paperstock in the outer layers of laminated combination boxboard, but this effect would not be closely related to monthly variations in price of paperstock.

The cross-elasticity of demand for paperstock with respect to the price of wood pulp, evaluated at the means, is 0.13. This does not seem to be unreasonably low, since most of the paperstock consumed is used in mills which customarily obatined 100 percent of their fiber requirements from this material; other users rely primarily upon captive long-term supply arrangements with prompt sources or dealers to supplement wood pulp inputs with high grade paperstock. Neither group is expected to shift its mix of fiber sources appreciably in response to short term price changes. Longer-run responses to changes in relative prices might be appreciably greater, however. The positive sign for the wood pulp price indicates that an increase in the price of wood pulp will positively affect demand for paperstock through substitution of the relatively cheaper fiber source.

If we assume that the error resulting from the use of an inaccurate woodpulp price series is independent of errors in the other independent variables, the bias in the estimated coefficient is downwards towards zero. Consequently, the estimated coefficient and calculated elasticity for the price of wood pulp are likely to be below the true value, understating the effect on paperstock demand resulting from an increase in the price of substitute virgin wood pulp.

A demand equation was estimated using the price of pulp substitute grade paperstock as a surrogate woodpulp price, on the grounds that this would be in equilibrium with the actual market price of woodpulp, separated only by a processing cost differential. Since the price of this paperstock grade is incorporated in the composite paperstock price used in the reported equations, a new composite paperstock price variable was constructed by averaging the prices of the three remaining bulk grades of paperstock. The new equation was estimated, but the coefficient for the pulp substitute grade of paperstock proved insignificant.

The demand relationship as specified omits several variables for which there exist no suitable data series. This omission may bias the estimated coefficients for the variables which are included.

Transportation charges are an example of a variable which should be incorporated in the full cost of obtaining paperstock. Two attempts were made to include transportation charges in the estimated demand equations. The annual average freight rate series (revenue per ton mile, all commodities, from ICC annual reports) was converted to a monthly series in the following manner. The annual average rate reported for each year was taken as the year end rate. The change from year to year was assumed to be smoothly distributed over the twelve month period. The calculated monthly freight rates were then converted to an index, with the average for 1957-59 as the base period. These rate indexes were then deflated using the WPI for all commodities.

Two new paperstock prices series were constructed, one allocating half of the full cost of paperstock to freight rates and the other allocating 30 percent to freight rates.

Demand equations were estimated using each of these paperstock price series. An additional equation was estimated including the constructed freight rate series as a separate variable, the cost of an input complementary to the use of paperstock. No satisfactory results were obtained with any of these equations.

(2) Supply

All estimated coefficients have the expected sign in the supply equation, and are significant at the 0.01 level. The elasticity of supply with respect to the current price, calculated at the mean, is 0.40. The sign and magnitude of the coefficient for the Almon lag structure imposed on past prices indicate that the elasticity with respect to price changes that persist for a few months. While response is positively related to current price, it is negatively related to past prices. The net longer-term elasticity is about 0.15.

The price elasticity estimates are consistent with considerable inertia in supply activity. Sustained price changes might well be met with considerably greater supply responsiveness than is indicated by our elasticity estimates, but the effect of long run adjustment does not unambiguously favor appreciable increases in supply elasticity, While investment in new capital and equipment will affect long-run supply responses, this factor may be partly offset by declines in material availability from prime sources and increased costs of recovery as exploitation extends beyond the most accessible materials.

The interpretation of the lag variable is obviously crucial to the use of these results for predictive purposes. The inclusion of a lag structure on past paperstock prices and lagged variables indicating activity levels at the prompt-generating production stage was supported in the discussion of model variables as an effort to accommodate some aspects of the supply process peculiar to the scrap industry.

The two separate variables are designed to capture the effect on supply of changes in the raw material resource base exploited by the wastepaper industry. The resource base for the wastepaper industry comprises flows from two reasonably distinct sources: industrial and post-consumer.

Apart from inventories of prepared paperstock held by dealers and brokers, and points at which residuals are accumulated prior to collection, we assumed that there is no stock of waste materials in the environment which is drawn down or permitted to build up depending upon the relative magnitudes of flows into the stock, deterioration of materials contained in the stock, and flows (extraction) from the stock. All "stocks" exist only at "way stations" in the supply process. This assumption rests on the observation that wastepaper which is not accumulated or collected for recovery as it is discarded, is effectively destroyed for recycling purposes.

A possible exception to this assumption is the storage of old newspapers by households, which may occur at some average level independently of a program of periodic, special collection services. Given a specific time period following the most recent special collection of newspapers in a prescribed area, it should be possible to estimate the likely magnitude of newspaper stocks which could be acquired with a special collection. The level of these stocks very likely will depend upon households expectations regarding provision and timing of special collection services, among other things.

If periods of high prices and accelerated recovery activities do result in the depletion of these pipeline inventories, then in succeeding periods any given level of supply flows will draw upon pipeline accumulations of lower average size and upon a mix of discard streams of reduced homogeneity. These factors increase collection and processing costs for any given quantity supplied, and reduce the amounts which the industry will choose to supply at any given price. During periods of depressed prices and recovery activity, holding point inventories will build up, and must either be supplied to users at the market price, or disposed of to make way for newly generated waste material.

The supply of paperstock includes substantial quantities of industrial scrap. We used the lagged Federal Reserve Index of production of converted paper products and paperboard containers as a measure of the industrial scrap component of supply. The calculated elasticity of .38 indicates that a one percent increase in this Federal Reserve production index increases the total supply of paperstock by about four-tenths of one percent. This elasticity is about what one would expect, given that industrial scrap comprises roughly this same percentage of total paperstock supply.

Several variables were omitted from the estimated supply equations due to lack of appropriate time series data. One of these, wages of unskilled labor, exhibited in annual series a smooth upward trend over the period in question. There is little evidence to the effect that this source of increased cost in what is a labor intensive industry was offset by the introduction of new technology.

A change in the paper and paperboard output mix may, however, have served partially to offset the effect of increased labor costs. The increase in use of corrugated container products provided an addition to the wastepaper industry's resource base which is easily identified, separated at source, and generated at relatively accessible sites. The growth in paper-using technology in the service sector of the economy contributed further to increased availability, since much of the discard from this site is homogeneous and of high volume.

A trend variable in the supply equation was included to measure these two effects. The variable proved insignificant indicating that the two may be essentially offsetting effects.

IV. CALCULATION OF TAX IMPACTS

The econometric model of the wastepaper market provides quantitative estimates of demand and supply parameters through which a change in tax treatment of virgin fiber resources has its impact on the recycling of wastepaper. These parameters and their estimated values are: the cross-elasticity of demand for paperstock with respect to the price of woodpulp, 0.13; the elasticity of demand for paperstock with respect to own price, 0.16; and the price elasticity of paperstock supply, 0.15. Together these parameters permit calculation of the percentage increase in wastepaper recycling which would follow a given percentage increase in the price of woodpulp.

Our data permit several alternative computations of the impact of capital gains taxation of stumpage profits on the recycling of wastepaper. The first will use the demand and supply elasticities as estimated and the maximum long-run price change in woodpulp attributable to capital gains. The second will assume long-run substitution between woodpulp and wastepaper is perfect (rather than limited by current capital stock and technology), and take supply elasticity and price effects as used in the first computation. The third computation will assume long-run substitution is perfect, take long-run supply elasticity as ten times our short-run estimate, and use a most-likely figure for the tax impact. The third alternative should provide an upper limit to the long-run impact of removing capital gains taxation of stumpage profits on the quantities of wastepaper recycled.

A. Case I

The maximum possible increase in the price of woodpulp which would result from removing capital gains treatment of timber income has been calculated earlier (in Ch. 6) as 4.2 percent. The effect of removing the capital gains provision would be to shift the demand curve for paperstock, increasing the amount of paperstock demanded at each price by 0.13 x 4.2% or .55%. The effect of this shift on the recycling of wastepaper given the supply curve as estimated would be an increase of 0.04 percent. This figure is obtained from a calculation analogous to that presented in chapter 6 to calculate the effect of a supply shift:

Percent change in wastepaper recycled

$$\frac{.55\% \times E_s \times E_d}{E_d + E_s} = \frac{0.55\% \times .15 \times .16}{0.16 + 0.15} = 0.04\%$$

At a present recycling level of close to 12 million tons per year, this translates to a 4,800 ton increase per year.

This is the recycling effect which can be inferred from the empirical basis provided by the econometric market study. The inference rests in part upon the assumption that the underlying structural conditions generating the data from which the parameters are estimated remain the same for the prediction period. The appropriateness of the model as specified and the suitability of the available data used to test the model have been dealt with at length earlier in the discussion of the econometric model and results.

These estimates are based on observations of month-to-month movements in the variables selected to describe the supply and demand relationships. The relationships so described are short-run--and no attempt is made to take account of influences on long-run investment decisions which in turn can alter the technological conditions underlying the industry behavior on both sides of the market.

A feature of industry technology which prevailed during the test period, and which would have important implications for the substitution possibilities between wood and paperstock--and hence for the pattern of demand behavior exhibited during htis period--is the dominance of industry capacity not equipped to use wastepaper as a fiber source. The present study has not attempted to provide a basis for predicting the possible contribution that a change in federal tax policy might make to redressing this situation. A perceived long-run change in relative costs of alternative fiber sources could affect decisions on incremental capacity in ways favorable to the increased use of secondary fiber.

The impact of such technological developments are not to be relegated solely to the "demand" side of the wastepaper market. Changes in fiber recovery and cleaning, and in paper and paperboard forming processes clearly would affect the necessary characteristics of suitable paperstock inputs, and by thus altering the desired outputs of the wastepaper collecting and processing sector change the availability and accessibility conditions affecting supply potential for secondary fiber. For example, an increased ability to use the shorter groundwood fiber in newspaper or to reduce the importance of contaminants in mixed wastepaper would permit the tapping of relatively abundant materials, much of which is no less accessible than the amounts of similar materials presently being recycled. Impetus to such developments may be provided by the growth of large and diversified solid waste recovery firms and vertical integration of the recovery and manufacturing processes.

Under technological conditions similar to those prevailing during the test period, longer-run elasticities may be greater than those calculated from the estimated model. Particularly on the demand side we would expect greater response to a change in relative prices as existing substitution possibilities are explored and exploited. Once new supplies of paperstock have been located and developed, this fiber source may be expanded in use at the expense of the relatively more expensive virgin woodpulp. On the supply side the longer-run picture is less clear since adjustment efforts to discover and collect additional tonnages of suitable inputs for desired output grades may be hindered by limited resource availability.

B. Case II

This case needs little discussion. The assumption of perfect long-run substitutability between virgin woodpulp and wastepaper is undoubtedly closer to the truth than is our elasticity estimate which is based on short-run responses to changes in market prices. Perfect substitutability would dictate that removal of tax subsidies to woodpulp production would result in price increases for both virgin and secondary inputs equal to the subsidy per unit. Assuming that the subsidy amounts to the full 4.2 percent of the price of woodpulp, the price of wastepaper would rise by this same amount, and the quantities of wastepaper recycled would increase by 4.2% x .16 = 0.67%.

C. Case III

As indicated in Chapter 6, the long-run impact of capital gains taxation on the market price of woodpulp is probably more on the order of one percent than the 4.2 percent used as the maximum possible effect. Assuming that the long-run supply elasticity is ten times our computed .15 estimate, or 1.5, and long-run substitution possibilities are perfect, the impact on recycling would be an increase of 1.5 percent.

CHAPTER 9

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CHAPTER 10

LEAD

Lead ranks fifth by weight in domestic metal production, exceeded by steel, aluminum, copper and zinc, in that order. The supply of lead for domestic consumption is derived from three major sources.[1] In 1973 secondary lead contributed 42.0 percent of domestic production, domestic mine output 39.5 percent, and imports 18.5 percent. The excess of 1973 domestic lead consumption of 1,541,209 tons over production of 1,525,328 tons was satisfied by inventory depletion of industry stockpiles.

In contrast to the steel industry which uses both virgin and scrap materials as inputs to the same production processes, virgin and scrap lead inputs are processed separately, often by totally different firms. Primary lead ore production is confined mainly to Missouri, Colorado, Idaho, and Utah, though some lead is also produced as a by-product of mining copper, silver, and zinc ores in other states.[2] Lead ores are processed near the mine to minimize transportation costs; smelters and refineries are located in Missouri, Nebraska, Texas, Idaho and Montana. Secondary lead supplies and secondary lead processing facilities are widely scattered throughout the country. The physical separation of the primary and secondary lead sectors is paralleled in differences in output mix. As we note later, the physical and economic separation of the two sectors simplifies econometric modeling of competition between the sectors.

This section is divided into five components:

1) Inputs to secondary lead industry
2) Outputs of the secondary lead industry
3) Outputs of the primary lead industry
4) Discussion of model specification and estimation
5) Evaluation of tax impacts.

I. INPUTS TO SECONDARY LEAD INDUSTRY

Of the three sources of lead scrap - home, prompt, and obsolete - home scrap accounts for about 2 percent of primary production and is included in the primary lead figures; prompt, in the form of drosses and residues, amounts to 15 to 18 percent of secondary lead inputs; and obsolete lead in the form of battery plates, cable lead, babbit, solder, type metal, and soft and hard lead supplies the remaining 82 to 85 percent of secondary lead inputs. The relative importance of various sources of lead scrap is shown in Table 10-1.

Table 10-1. Sources of Scrap Lead

Scrap Source	Tons of Lead Recycled	Percent of Total Scrap
Batteries	350,000	60
Drosses and residues[a]	88,000	15
Lead alloys		8
Type metal	29,000	
Bearing metal	10,000	
Solder	9,000	
Cable sheathing	32,000	6
Ammunition	5,000	1
Miscellaneous obsolete scrap	62,000	10
TOTAL	585,000	100

[a] Drosses are metallic substances which are skimmed off the surface of molten metals.

Source: National Association of Secondary Materials Industries, Inc., Lead, 1969, p. 213. (Hereafter termed NASMI Report)

The estimated life cycles of various sources of lead scrap are shown in Table 10-2:

Table 10-2. Sources, Life Cycles and Recycling of Lead

Sources	Life Cycle (years)	Percent of Available Lead Recycled
Batteries	2.3	72
Drosses and residues	0.1	100
Lead alloys		
Type metal	2.0	100
Bearing metal	20.0	30
Solder	20.0	14
Cable sheathing	40.0	25
Ammunition	0.5	6
Miscellaneous obsolete scrap	30.0	62

Source: NASMI Report, p. 212

Using these figures, the quantities of lead theoretically available for recycling in 1969 was determined. For example, lead sheathings for cable are used for approximately forty years before they are scrapped. The quantity of lead used in the production of cable sheathing in 1929 is the approximate amount available for scrapping in 1969. Once the figures of lead available for recycling are calculated, the percentage of available lead actually recycled in 1969 can be obtained. These are also provided in Table 10-2.

Only six percent of the available ammunition lead available in 1969 was recycled. This low rate of recovery is attributable to difficulties encountered in collecting the shot from areas where it is relatively concentrated. Unless the price of lead rises considerably, recycled ammunition will continue to originate only at target ranges.

The percentages of the available lead based alloys, bearing metals, solders, and type metals, which are recycled, vary over a wide range. The greatest single use of lead alloys is type metals used in printing plates for type making purposes. Nearly 100 percent of type metal scrap is recycled. Lead-base alloys used as bearing surfaces for rotating parts are usually a small constituent of a much larger system of other materials. For example, an automobile engine contains a small amount of lead in the bearings. Just as it would not pay to disassemble an auto engine for its lead bearings, it is not economically feasible to recover 70 percent of the theoretically available bearing lead. This condition is likely to remain unchanged in the future.

Only 14 percent of available solder scrap is recycled because, in most uses, the lead becomes intimately attached in tiny quantities to much larger quantities of other materials such as copper and steel. Collection of this lead depends on the value of the metal to which the lead is attached. In a minority of cases, it is economically feasible to separate the solder from the other material. The NASMI report claims that this is an area with some room for improvement in recycling.

Approximately six percent of scrap lead is from lead cable sheathing Before it is ready for the smelters, lead cable has to be passed through a cable stripping machine which cuts the lead sheathing and peels the inner core of the cable. The stripped lead cable covering is then cut into small enough pieces for feeding into the smelting pots. To facilitate ease of handling, it might also be compressed in a hydraulically operated press.

Seventy-five percent of the scrap lead cable sheathing theoretically available in 1969 was not recycled. This type of lead scrap is economically feasible to recycle, so it is difficult to explain why so little has been recovered. Part of this may be explainable by errors in reporting by secondary scrap processors and smelters. Error is also introduced by basing the quantities available for recycling on life cycles. And finally, some lead sheathing is very likely reported in the "Miscellaneous obsolete scrap" category. However, it is difficult to see how such errors can account for more than one-half of the apparent loss of cable sheathing scrap, and so this is a category in which an increase in the recycling rate of lead is possible.

Ten percent of the total scrap used by the secondary lead industry in 1969 was from miscellaneous obsolete scrap. This figure represents 62 percent of the scrap theoretically available for recycling. Miscellaneous obsolete scrap, like solder scrap, includes a wide variation in the types of application so that some lead (weights and ballasts, sheet, pipe and fittings) is easily recyclable while others (foil, collapsible tubes, terne metal) are economically prohibitive to recover. The recycle rate for miscellaneous obsolete scrap is relatively high and, as in solder scrap, it is unlikely that more than a minor amount of additional lead can be expected to be recycled.

Battery lead plate is by far the largest single source of lead scrap, accounting for 60 percent of the total lead-base scrap smelted in 1969. Although automobile batteries are the most commonly used source of battery scrap, other used batteries come from railroads, industry, farms and military demolition. During 1969, 135,000 tons or 28 percent of battery lead theoretically available for recycling was not recycled. This is quite a high figure, given the fact that battery recovery is generally economically attractive. As in lead cable sheathing, these apparent losses of battery scrap may in part be due to error in reporting: some of the battery lead scrap maybe included in the figure under "Miscellaneous obsolete scrap", and/or scrap processors may be giving incomplete figures. The method of using life cycles of the scrap metal to estimate the theoretical availability of a particular scrap is probably not likely to be as inaccurate for battery scrap as it is for cable sheathing scrap since the life span of batteries is substantially shorter. At any rate, the NASMI report estimates that error in reporting cannot account for more than one-fourth of the loss of battery scrap lead. This would mean that the actual loss of battery lead scrap would still be more than 100,000 tons in 1969. The report explains some of these losses by storage losses in private homes and garages, military battery losses, and discards into trash collection channels. It is conceivable that the losses in battery lead scrap is a promising area for increased recycling.

II. OUTPUTS OF THE SECONDARY LEAD INDUSTRY

Two operations process scrap lead into intermediate products. The reverberatory furnace accepts a charge of battery plates, drosses, residues, and other lead scrap, and yields as outputs crude semi-soft lead and a leady slag. The blast furnace may be used to process slag from the reverberatory furnace, recycled slag from a blast furnace, drosses, oxides, and battery plates into hard, antimonial lead.[3]

Pot furnaces enable the crude semi-soft lead produced by reverberatory furnaces and the hard antimonial lead produced by blast furnaces to be brought to desired residual alloying percentages.[4] When commencing with a metal containing less residual alloy than is desired, additional alloying materials are added directly to the pot furnace. When the residual contamination of antimony and copper in semi-soft lead is undesirably high, sulfur is added to the molten alloy in a pot furnace and the mixture is stirred. Copper sulfide is skimmed off as a dross. Antimony may be removed by bubbling air through the molten lead.

When the residual alloy contamination of scrap can be controlled, processing in pot furnaces may be unnecessary. For example, the hard lead produced by a blast furnace will contain sufficient antimony to be used directly as an input to new battery plate production, provided such antimony rich inputs as battery plate and reverberatory furnace slag are fed to the blast furnace.

The relative importance of various markets for secondary lead is given in Table 10-3.

Table 10-3. Markets for Secondary Lead

Secondary Lead Markets	Percent of Total Market(1970)
Batteries	70
Tetraethyl lead	13
Solder	5
Type	4
Cable	3
Other	3
Bearings	2

Source: Derived from figures in NASMI Report, p. 213.

Storage batteries account for about 60 percent of scrap lead inputs. An approximately equal percentage of outputs of the scrap lead sector is devoted to the production of grids and paste for storage battery plates. Because of the overwhelming importance of storage batteries to the secondary lead industry, the recycling of storage battery plates will be analyzed in some detail here.

The typical automobile battery contains about twenty pounds of lead, most of which is found in the battery plates. The plates are composed of an antimonial lead grid whose interstices are filled with a lead oxide paste. A plate contains about half hard lead (antimony content ranging from 7 to 12 percent), and half soft lead oxide paste (less than one percent antimony).

Plates which have been removed from spent storage batteries may be smelted in a blast furnace or processed in a reverberatory furnace. The blast furnace is more efficient and is normally used when antimonial lead is the desired output. To produce a hard lead output, additional antimony must be fed to the blast furnace for the antimony content of an entire plate averages only four to five percent antimony, or some three to seven percent less than is required in antimonial lead.

Plates melted in a reverberatory furnace yield about one-half soft lead and one-half lead antimonial slag. The slag requires further smelting in a blast furnace to recover the lead.

Antimonial lead produced by the blast furnace may be used directly in the manufacture of grids for new battery plates. Normally the grids are cast by pouring molten lead into an iron mold and allowing it to solidify. Litharge, the lead paste for battery plates, is a mixture of lead oxide (obtained by oxidizing soft lead in a furnace), finely divided metallic lead, and water.

III. OUTPUTS OF THE PRIMARY LEAD SECTOR

The primary lead industry mines ore, concentrates the ore, and processes lead concentrates in blast and pot furnaces.[5] The principal source of lead is galena, a lead sulfide. In addition to sulfur, galena usually contains appreciable quantities of zinc and antimony. Normally lead ores require concentration through differential flotation or a similar process before they are smelted. Smelting burns off the sulfur (oxidation), and reduces lead oxides to metallic lead. Pot and kettle furnaces are used to add or remove other metals in a process known as refining.

Most lead bearing ores contain significant quantities of other metals. The Missouri ores, the source of about three-fourths of domestic production in recent years, contain about one part zinc for every six parts lead. Many Idaho ores contain lead and zinc in roughly equal concentrations as well as significant quantities of silver. Colorado lead ores typically contain more zinc than lead as well as copper in concentrations justifying its separate recovery.

After a long period of decline which began in 1950, primary lead output nearly doubled in the five years from 1967 to 1972. A three-fold expansion of Missouri output accounted for all of the recent increase as production shifted from the Old Lead Belt to the New Lead Belt fifty miles to the west.

Although lead ores contain antimony in appreciable quantities, and would therefore appear ideal for the manufacture of hard lead outputs, most lead is refined in pot furnaces to produce soft lead. Less than two percent of the output of the primary sector is hard, antimonial lead. Soft, refined lead has a wide variety of end uses, including the gasoline additive tetraethyl lead, cable sheathing, lead oxides, pigments, and a variety of lead alloys.

IV. MODEL SPECIFICATION

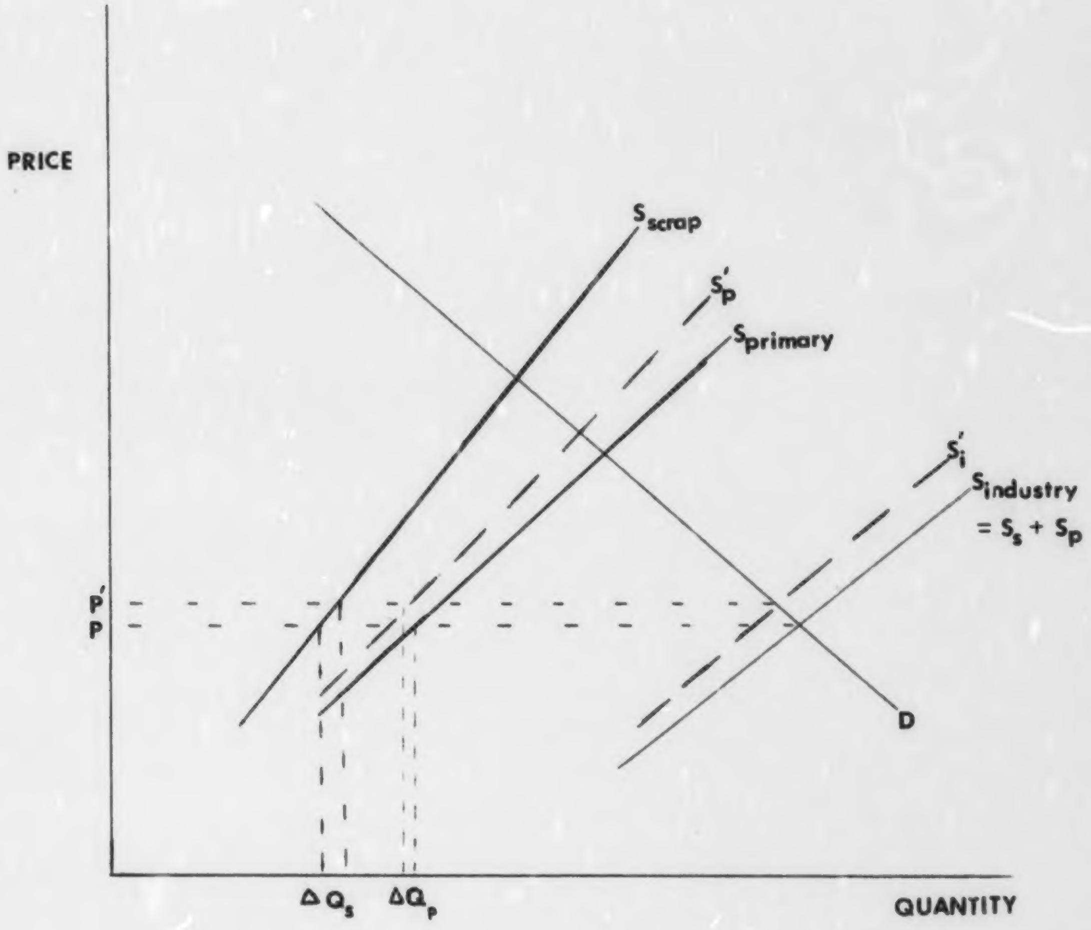
The discussion of lead industry outputs revealed that primary and secondary sector outputs are substantially identical, but proportion of total output devoted to antimonial lead, soft refined lead, and lead alloys varies considerably between the two sectors. This indicates that cost increases in the primary sector would make the primary sector relatively less competitive and could induce a substantial shift in the quantities supplied by the two sectors in the long run.

The relevant analytical model for predicting the long run impact of altered cost conditions in primary production assumes primary and secondary outputs are perfect substitutes and can be linearly added to form the lead industry supply curve. The intersection of supply and demand determines the equilibrium price for lead outputs. A tax induced shift in the hypothetical primary industry supply curve (as depicted in Figure 10-1) shifts the industry supply curve, and hence changes market price. The new equilibrium quantities supplied by each sector can be read from the graph. In Figure 10-1 the upward shift in the primary sector supply to S'p results in a new equilibrium price of P', an increase in secondary lead output of ΔQs and a reduction in primary lead output of ΔQp.

The key to the empirical analysis of the market model is to develop long run parameter estimates for sectoral supply curves and for the industry demand curve.

FIGURE 10-1

SUPPLY AND DEMAND FOR LEAD



A. Primary Production

Mine production of lead was modeled in terms of distributed lags with mine output being influenced by past as well as present independent variables. We used the Koyck distributed lag model, which can be derived from a stock adjustment hypothesis as follows.

Denote the quantity of lead supplied in year t by Q_t and the price received by producers by P_t. Let Z_t represent the price of the co-product, zinc, in year t. Given these prices, producers would like to furnish Q^*_t which depends on prices according to the long-run supply equation

$$Q^*_t = a + bP_t + cZ_t \tag{18}$$

Since it requires time for supply to reach the desired level, producers do not immediately offer Q^*_t in response to new values of price. If it is assumed that it is only possible to adjust by some fixed fraction θ of the desired amount in any year, then

$$Q_t - Q_{t-1} = \theta(Q^*_t - Q_{t-1}) \tag{19}$$

Substituting (19) into (18) and rearranging

$$Q_t = \theta a + \theta bP_t + \theta cZ_t + (1-\theta)Q_{t-1} \tag{20}$$

In this model the short-run effect of price on supply is given by θb, and the long-run effect is given by b directly. The smaller is θ, the slower the rate of adjustment and the greater the difference between long-run and short-run effects.

The estimation of equation (20) by ordinary least square encounters two difficulties. First, both prices are endogenous to the model (though the price of zinc could be assumed exogenous) and biased coefficients are to be expected unless two stage least squares or a similar estimating procedure which recognizes the simultaneous nature of P_t and Q_t is used. Second, if the error term in the equation is autocorrelated the estimates will be inefficient. Autocorrelation is quite likely in such a model and can be treated only by assuming a specific order of the relation among the errors. The computation algorithms available to project researchers limited us to a first order autocorrelation model. Denoting the error term in

(20) by u_t we assumed

$$u_t = pu_{t-1} + e_t \tag{21}$$

where e_t was assumed to have mean zero and variance-covariance matrix $\sigma^2 I$. Equation (20) was estimated by choosing estimates of p and other parameters to minimize the sum of squares of e_t. As noted by Cooper, the estimator is consistent and if e_t is normally distributed also a maximum likelihood estimator.[6]

Data for the equation were taken from Minerals Yearbook. Mine production, Q_t, is mine output of primary lead in thousands of short tons, and price, P_t, is the producer price of lead in cents per pound divided by the U. S. wholesale price index (1957-1959 = 100). The supply equation was estimated by two stage least squares using as predetermined variables: the price of zinc lagged once and twice, the Federal Reserve Index of industrial production, and a linear trend. Primary supply is:

$$\underset{}{Q_t} = -4.19 + \underset{(4.21)}{11.58P_t} + \underset{(3.70)}{.45Q_{t-1}} \tag{22}$$

$p = -.002$

Years: 1949-1967

In this equation the figures in parentheses are the t ratios of the estimated coefficients to their asymptotic standard errors. Small sample tests of significance have not been developed for such estimates, but others have assumed that a t ratio of 2 or more indicates a statistically significant relationship (see Fisher et. al.)[7] As indicated, the years from 1968 on have been omitted, primarily because the doubling of national primary lead output from 1967 to 1972 following development of the New Lead Belt in Missouri was related more to technological factors than to changes in market price or demand. The price of zinc proved to be insignificant and was dropped from the primary supply equation.

The speed of adjustment in primary lead supply is fairly rapid. Over half (1.00 - .45) of the gap between desired and actual production is achieved each year. Thus, the difference between short and long-run supply elasticities is relatively small. At the point of means for the period the short run price elasticity of supply is about .55 and the long-run elasticity is about 1.0.

B. Secondary Production

The principal sources of secondary lead are recycled battery plates, drosses, and residues, and miscellaneous collections of recyclable cable sheathing, solder and type metal. All attempts to formulate a distributed lag model of secondary output produced negative, albeit insignificant, coefficients for the lagged dependent variable. This could be explained if high output in one period tends to deplete the inventory of obsolete scrap available for recycling in subsequent periods. The conspicuous failure of the distributed lag approach led us to model secondary output, S_t, as a function of current price; P_t, lagged battery production; B_{t-2}, to represent availability of scrap; and current primary production, R_t, which is a possible source of drosses and residues.

The supply equation was estimated by two stage least squares using as predetermined variables the once and twice lagged price of zinc, the Federal Reserve Index of industrial production, and a linear time trend. Both primary production and lagged primary production proved insignificant and were dropped from the equation. Secondary supply was estimated as:

$$S_t = 27.29 + \underset{(7.49)}{18.23P_t} + \underset{(18.1)}{2.98B_{t-2}} \qquad (23)$$

Years 1954-1972

As with primary production, output is in thousands of tons, and price is in cents per pound. Battery production is the Federal Reserve Index of replacement storage battery production, 1967 = 100. The fit for the equation is quite good. At the means for the period the estimated elasticity of output with respect to price was .48. The equation excluded the years prior to 1954 because the Federal Reserve Index of battery production began that year.

C. Consumption

The more significant end uses of lead are storage batteries, tetraethyl lead, pigments, type metal, cable sheathing, ammunition, and bearing metal. The level of demand for many of these end uses appears to be closely linked with general industrial activity. Others, principally storage batteries and tetraethyl lead additives, appear to be related to the ownership and use of automobiles. Because the production of storage batteries and gasoline additives are components of general industrial activity, it would not be appropriate to include in the demand equation both an index of industrial production and a separate index of gasoline or battery output as determinants of lead consumption.

Other variables which could be important determinants of demand are the price of lead, the price of lead substitutes, and measures of the stock of lead held in inventory of semi-manufactured goods. Clearly, the price of lead should be included in any specification of demand, but just what constitutes a lead substitute and measures of lead held in manufactured goods inventories are difficult to determine. Lead has substitutes in battery production, including the metals nickel and cadmium, but all substitutes are far more expensive and are reserved for special applications where low weight or long life are critical. A similar situation pertains to other lead uses; with the exception of cable sheathing, where substitutes exist they are considerably more expensive. Substitution of other metals for lead in the past twenty-five years may have occured in response to technological change or to avoid potential lead poisoning of humans, but substitution in response to changes in lead prices has probably been insiginificant, given that lead has been far cheaper than substitute materials during this period. Because there are no data on inventories of fabricated products embodying lead, and other data series which were available, such as durable goods inventories, are poor measures of this form of lead in inventory, the inventory aspect of lead demand was not included in the econometric demand specification.

The demand equation was first formulated in terms of distributed lags in which the current value of consumption depended on current and past values of the independent variables. When this failed (the coefficient of price was positive and that of lagged consumption negative) the equation was specified in terms of contemporaneous values of all variables. The demand equation was estimated by two stage least squares using as instruments the lagged values of price, secondary production of lead (once and twice lagged), the lagged value of consumption, and the lagged value of industrial production.

In the equation reported below, consumption, C_t is in thousands of tons; price, P_t, is in cents per pound; and industrial production is the Federal Reserve Index of industrial production. Consumption and price data were taken from the Bureau of Mines' Minerals Yearbook. Price data were divided by the wholesale price index (1967 = 100). The Durbin Watson statistic was low in the original equation, and, therefore, the serial correlation correction discussed previously was used in the final round of estimation. Demand was estimated as:

$$C_t = 711.3 - \underset{(2.62)}{17.31P_t} + \underset{(4.94)}{10.23I_t} \qquad (24)$$

ρ (the serial correlation coefficient) = .938

Years: 1949 - 1972

At the means for the period the price elasticity of demand was estimated as .21, indicating that consumption is largely unresponsive to changes in market price. This is to be expected for an input that is low in value relative to the final output price (as it is in pigments, gasoline additives, and bearings), or has few or no substitutes at present price levels (as in storage battery production).

V. EVALUATION OF TAX IMPACTS

In this section we use the econometric results to estimate the impact of virgin material tax preferences on incentives to recycle scrap lead products. The estimates assume the virgin lead supply curve is shifted by the full amount of the tax, that is that all taxes and subsidies are passed forward into product prices.

One of the assumptions underlying the computation is that we have captured the entire lead supply by estimating mine output and secondary production. Since lead imports have ranged from about 15 to 25 percent of total consumption in recent years, this assumption is clearly violated. On the other hand if lead imports do not respond to changes in the price of lead this segment of supply may be ignored. To test the relationship between lead imports and the price of lead a separate import equation was estimated. In all specifications the price of lead was insignificant leading us to drop imports from further consideration in the computation of industry supply elasticity.

Referring again to Figure 10-1 and to the estimated elasticities, we may calculate the impact of an increase in the price of virgin lead output attributable to removal of the mineral depletion allowance on the quantity of scrap lead recycled. The elasticity of the industry supply curve is equal to the weighted average of primary and secondary elasticity, or .6. The supply curve for final lead outputs is shifted by .4 percent for every one percent increase in the supply curve for primary lead. As indicated in Chapter 6 (page 111), the maximum impact of percent depletion on the primary supply curve is about 5.3 percent. This suggests that elimination of percent depletion would increase the lead industry supply curve by at most 2.1 percent. The equilibrium price of lead would rise by an amount equal to the product of the percent shift in supply and the supply elasticity, divided by the sum of supply and demand elasticities (see page 88 for details). If percent depletion results in a shift of primary supply of 5.3 percent, the equilibrium price of lead would rise by 1.6 percent and the consumption of scrap lead would rise by 1.6 percent times the scrap supply elasticity of .48 or 0.75 percent. The other tax preferences, such as expensing of exploration and development would have even smaller impacts.

CHAPTER 10

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CHAPTER 11

COPPER

Copper ranks third by weight in domestic metal production behind steel and aluminum. The secondary copper industry is the largest of the nonferrous secondary metal industries. In 1972, secondary copper production amounted to 1479 thousand tons, of which about two-fifths was old or obsolete scrap and three-fifths was new or prompt scrap.[1] The total represented approximately 42 percent of the total supply of copper for that year.

Primary copper production from the states of Arizona, Utah, New Mexico, Nevada, and Montana, accounts for over 90 percent of primary domestic copper production.[2] A few large corporations dominate the primary copper industry. Although the same firms are also factors in the secondary copper industry, their share of output is much lower. Primary and secondary copper substitute at a number of different points in the materials flow of the industry, making accurate econometric modeling of competition between the two sectors virtually impossible. In this Chapter we took two alternative approaches. One was to attempt to identify those points where substitution of primary and secondary copper actually occurs, and base the econometric estimates of supply and demand on the quantities observed at the points of substitution. The second was to assume that in the long run there would be perfect substitution between the final outputs of the primary and secondary copper industries, and estimate the supply equation for all obsolete scrap. Of the two approaches the second should provide the more optimistic assessment of the impact of increasing the tax burden of primary producers on the quantities of scrap copper recycled.

The chapter is organized into five sections:

1) Inputs to the secondary copper industry
2) Outputs of the secondary copper industry
3) Outputs of the primary copper industry
4) Discussion of model specification and estimation
5) Evaluation of tax impacts

I. INPUTS TO COPPER INDUSTRY.

Almost half of the secondary copper recovered is classified as obsolete scrap. In 1969, 44 percent of all copper scrap recycled was obsolete scrap, with the remainder obtained from prompt industrial scrap.[3] Table 11-1 below shows the major identifiable material sources of copper scrap, as well as the amounts of copper recycled from that source as both prompt and obsolete scrap.

Table 11-1. SOURCES OF SCRAP COPPER

Source	Copper content recycled (1000 short tons)	%of total	% Prompt	% Obsolete
Electric Wire and copper	699.1	54	54	46
Cartridge brass	128.2	35	59	41
Automotive radiators	48.5	3	-	100
Low grade scrap and residues	37.2	3	100	-
Other scrap	18.9	1	68	32
Railroad car boxes	20	1	-	100
Magnet wire	13.5	1	-	100

Source: Battelle Memorial Institute, A Study to Identify Opportunities for Increased Solid Waste Utilization, Volumes II to VII, 1972, p. 146 (hereinafter referred to as "Battelle Report")

Prompt scrap usually is a material of known composition and is relatively free from impurities. These qualities are very desirable to consumers and it can be assumed that virtually all the available prompt scrap enters supply channels and is recovered.

Obsolete scrap is more complex. Copper products become potentially available for recovery once they enter the market. However, the year in which each end-use quantity becomes available for use as scrap depends on when the product becomes obsolete. This is determined by each product's life cycle. By applying the average life cycle for products in various market categories to historical consumption data, an estimated figure for the "potential supply" of obsolete copper scrap may be obtained. Table 11-2 shows the potential annual availability for several major identifiable material sources of scrap copper as well as the percentages of scrap actually recovered in each category.

Table 11-2. POTENTIAL AND ACTUAL COPPER RECYCLING FOR MAJOR END USES

Material source	Life cycle	Available (in 1000 short tons)	Percent recycled	Percent prompt recycled	Percent obsolete recycled
Low grade scrap & residues	5	37.2	100	100	-
Other scrap	?	18.9	100	100	-
Automotive radiators	12	53.0	91	-	91
R.R. car boxes	3.5	22.6	88	-	88
Wire & tube	45.0	850.9	82	100	68
Cartridge brass	.5	204.9	63	100	31
Other brass	30.0	1,013.3	52	100	30
Magnet wire	10.0	158.	9	-	0
Alloying additives	14.0	96.9	0	-	-

Source: Battelle Report, p. 146.

On weighted average, the life cycle of all copper products is approximately 17 years, and about 40 percent of the total obsolete scrap available is actually recovered.

Of the total copper contained in an automobile, about 10 pounds is found in the radiator. This item is relatively easy to remove, and the recovery rate from this source of copper is high. In addition, the amount of copper potentially available from this source represents only a small percentage of the total obsolete scrap available. Even if all of the 4.5 thousand tons of copper scrap in automotive radiators that are presently not recycled were recovered in response to a price change, this would still represent less than a one-half of one percent increase in supply.

The same is true for copper scrap from railroad car boxes. The rate of recovery of secondary copper from this source already is high; and even if all of the copper from this source were to be recycled, it would increase the total supply of obsolete copper by only one fifth of one percent.

Two of copper's properties, its electrical conductivity and ductility, explain its wide use as an electrical conductor in the form of wire. Silver is the only metal whose electrical conductivity is better than that of copper, but its added cost does not justify its widespread use in electrical applications. Recycled copper wire and tube is a large source of copper scrap, and any increase in the 82 percent of copper wiring already recycled will significantly add to the total supply of copper scrap.

The main applications for copper falling in this category include insulated communication wire and cable, power wire and cable, plumbing tube for buildings, and insulated appliance wire.

Nearly 100 percent of the copper cable used by utilities and phone companies is already recycled.

Formerly, most of the copper scrap from houses and other buildings was recovered as demolition waste when the building was torn down. But with the increasing costs of semiskilled labor, there has been an incentive for the demolition contractor to consider copper salvage to be uneconomic and, as a result, dispose of scrap from this source in dumps or sanitary landfills.

Most cable and wire has been insulated with either lead, paper, rubber, cloth, asbestos, or polyethylene. The problem of removing this insulation has become more complicated by the trend towards more stringent air pollution control. Incineration is the traditional method used by the industry to remove the insulation. It has been the most convenient and least expensive method available. However, combustion is not complete when this material is burned, and so a soot forms. The gaseous pollutants created by this method lessens its attractiveness.

Use of organic solvents has been proposed, but it is difficult to find a universal solvent for the different types of insulation. Mechanical methods such as stripping, chopping, grinding, or hot pressing does not pollute the air as much as burning and it also produces a cleaner product. These procedures, though, are more expensive than burning, and they become more and more ineffective if the conductor is part of a complex electronic system. Incinerators which include suitable fume collection, afterburning and gas scrubbing equipment have been developed but these are quite expensive. Because of the increased costs of stripping copper wire, whether done by mechanical methods or by more sophisticated burning equipment, a drop may be seen in the amount of electric wire and copper tubing that is recycled.

Electrical appliance uses are widespread and, often, the copper item is only a small fraction of the total product. The scrap processor, at present, has little economic motivation to recover consumer appliances because handling and transportation costs exceeds the scrap value of the product.

Because of their bulk, appliances are not easily incinerated. Some attempts are made for salvage of major appliances by using new shredding techniques developed primarily for recovery of automobile scrap, but, for the most part, the 21 million appliances which are sent to landfills by scrap collectors or other disposers are not recovered.

It is estimated that of the 32 percent of obsolete copper wire and tubing which is not recycled, between 9 and 18 percent of it is in consumer appliances. Since it appears that it is very expensive to recover scrap from this source, a small increase in the price of secodary copper probably would not increase the supply of copper from appliances in any visible way.

The remaining 14 to 23 percent of obsolete electric wire and copper tubing which is not presently being recycled, representing between 66 thousand and 108 thousand tons of scrap annually, may be quite price elastic. Present secondary copper prices exceed or are at least in the same neighborhood as costs for recovery in these other applications of wire and tubing because, unlike appliances, much of the copper from these sources is already being recovered. An increase in the price of secondary copper might make the implementation of the already developed new wire stripping techniques economically feasible and it might encourage quicker development of other anti-pollution techniques. In the construction industry, a rise in the secondary copper price may help to cover the increase costs of semiskilled labor, and the contractor may no longer find it economically prohibitive to recover demolition waste.

Approximately 69 percent of the potentially available obsolete cartridge brass is not now being recycled. This represents almost 78 thousand tons of copper annually, or five percent of the total available obsolete copper scrap. Used for small arms and ammunition artillery shells, cartridge brass is fired mostly at domestic military bases and in battlefields. During the Viet Nam conflict, the use of cartridge brass increased substantially and much potential scrap from arms was lost forever. However, the quantity of scrap recovered from domestic military bases probably is sensitive to secondary copper price changes. Although the cartridge brass is often spread over many square miles of land, recycling of this material should not be very difficult because it is easily recognizable and quite valuable.

Some 489.4 thousand tons of obsolete copper scrap in the "Other Brass, Cast and Wrought" category that is potentially available is not presently being recycled. This represents a large chunk of the available obsolete scrap supply--approximately 30 percent. There are a myriad of applications for products from the brass mill and brass foundry industries, ranging from hardware to coinage to watches. Therefore it is difficult to pin-point which of these various end-uses of brass products can easily increase their recycling rates. On the basis of prior knowledge alone it is difficult even to guess how responsive supply will be to increases in prices. Econometric estimation of a supply equation for obsolete copper scrap would be especially useful as a means of providing this information.

Magnet wire is used for windings in motors and generators. Many of these motors are fractional horsepower size for household appliances. These contain small amounts of copper individually, but large amounts in aggregate. As has been mentioned, almost all of these appliances end up staying in landfills. Larger motors contain larger amounts of copper, but they consume less in aggregate. Because copper windings are usually surrounded by iron, simple recovery of them is that much more difficult. An estimated 144.5 thousand tons of available magnet wire, accounting for approximately nine percent of the total available obsolete copper scrap, is not presently being recycled. It does not appear that there would be any significant increase in the amount of scrap in this category that would be recycled in response to a marginal increase in the price of secondary copper.

Copper products which are not recovered are either 1) dissipated beyond recovery, 2) disposed of in solid wastes, or 3) scattered throughout the country.

Copper in the "Copper Alloying Additives" category is an example of copper scrap that is dissipated beyond recovery. Although approximately 96.9 thousand tons of this copper, which is used by the steel, chemical, aluminum, and other industries as an alloying additive, are theoretically available for recovery as scrap material, virtually none of it is recovered. In these applications, copper is a minor part of a much larger system. For example, copper used as an alloying element in either aluminum or steel is often present in amounts under one percent. It is simply economically unfeasible to separate copper from the alloy in these instances. Hence, there is little opportunity for increasing teh recovery of copper scrap from this source. In addition, approximately 10,000 tons of copper are emitted in flue dusts from stack emissions annually in the United States. Even with more air pollution controls, this copper will probably continue to be lost simply because the material contains low concentrations of the metal.

Solid waste disposal sites, particularly in urban areas, presently receive as much as 30 to 50 percent of the unrecovered copper products. An estimated 40 million tons of copper have accumulated as urban refuse.

Table 11-3. COMPOSITION OF INPUTS TO INTERMEDIATE CONSUMERS

Scrap type	Percent of total used by consumers			
	Ingot producers & secondary smelters	Brass mills	Foundries and other	Primary producers
No. 1 wire and heavy copper	20.1	19.5	9.7	32.4
No. 2 wire, mixed heavy and light copper	34.5	4.8	19.2	13.8
Copper base	0.5	15.7	58.1	48.6
Low-grade scrap and residues	44.9	0.0	13.0	5.2

Source: Battelle Report, p. 140.

The remaining unrecovered copper is widely dispersed throughout the country, and largely unaccounted for. For example, some of these products are in storage and essentially obsolete. Depending upon scrap prices or innovative collection methods, these products may be recovered as secondary copper.

Copper in disposal sites and copper unidentified as to its whereabouts fails to enter the recovery cycle because of inadequate economic incentives. Improving the economic feasibility of recycling copper in disposal sites is more likely simply because copper is more concentrated at this source.

II. OUTPUTS OF THE SECONDARY COPPER INDUSTRY

The markets for copper scrap are not concentrated. Several different kinds of plants, known as intermediate consumers, purchase unprocessed scrap from industrial plants and partially processed scrap from dealers engaged in scrap recovery. Engaged in one phase or another of secondary copper production are approximately 80 secondary smelters and ingot makers, 50 brass mills, several hundred foundries, and about a dozen primary producers.[4]

The pattern of materials flows among these intermediate consumers is rather comples. Brass mills, foundries and primary producers consume both scrap and virgin copper as inputs so that some substitution of primary for secondary materials occurs within these firms. Secondary smelters and ingot makers consume almost entirely scrap copper. In some cases their outputs, which are made entirely from scrap, compete with the outputs of the other intermediate consumers, which contain virgin copper inputs. In these cases, increases in the relative shares of secondary smelters and ingot makers imply that substitution of scrap for virgin copper is occurring. In other cases the outputs of secondary smelters and ingot makers are used as inputs to other intermediate consumers. Where this occurs there is also potential for substitution of scrap for virgin copper.

Historically, brass mills have consumed about 56 percent of the prompt industrial scrap and three percent of the obsolete scrap, or about 35 percent of all copper scrap. Primary producers have purchased about 30 percent of prompt and 35 percent of obsolete scrap, or approximately one third of all copper scrap. Foundries have accounted for approximately three percent of prompt and 12 percent of obsolete, or some six percent of the total. Secondary smelters, ingot producers, and (to a very limited degree) chemical plants account for the remainder.

Almost any kind of copper base scrap can be used to produce copper metal and alloys which are equal in metallurgical quality to outputs of the primary copper industry. Differentials in processing and transport costs have influenced the evolution of various sectors of the copper industry to the extent that certain distinct inputs and outputs have become characteristic of each of the intermediate processors. Table 11-3 shows the consumption of purchased copper scrap by the four main intermediate consumers in the year 1969.

There are two kinds of secondary plants. Ingot fabricators merely remelt alloy scrap and sometimes blend it with primary metal to obtain a specified ingot. Secondary smelters and refiners can remove the impurities from low grade scrap to produce unalloyed refined copper. Secondary smelters use lower grades of metal input than do brass mills and foundries. The output of secondary smelters and ingot fabricators substitutes in some uses for virgin based outputs of the other intermediate consumers.

The brass industry, including mills that produce copper wire, accounts for about 85 percent of total U.S. copper consumption. The metal, in turn, constitutes approximately 90 percent of the raw material inputs to the industry. Slightly less than half of the input of copper to the industry is in the form of high-grade scrap. Nearly all of the scrap consumed by these plants is segregated prompt scrap recycled directly back to the mills as a by-product of metal fabrication. Because the use of obsolete scrap by the brass industry is limited by technological constraints, the opportunities for increasing the flow of scrap to this industry in response to changes in virgin copper prices appear to lie mainly with high-grade prompt scrap. Inasmuch as almost 100 percent of this is already recycled, the brass industry does not offer significant opportunities for greater recycling. Of late, the brass industry has been beset by hard times and many mills owned and operated by primary copper producers have been closed.[5]

Foundries consume alloy ingot produced by secondary smelters. In addition, foundries purchase significant quantities of primary metal and high quality scrap. Castings, which are the principal foundry output, are used in a variety of applications ranging from railroad journal bearings to plumbing valves. The foundry industry has been declining for some time due to substitution by materials such as stainless steel, aluminum, zinc alloys and plastics, and presently accounts for about six percent of copper scrap consumption.

Primary smelters use low grade scrap and residues, including significant quantities of obsolete scrap. Scrap which is high in iron is necessary in matte, an intermediate product in the operations of the primary smelting plant. As refiners, primary producers aim to recover the copper content of scrap, preferring high quality No. 1 and No. 2 copper scrap which are the least expensive to refine.

There appear to be few if any constraints on the amount or quality of copper scrap that can be smelted by primary producers. With proper sorting and processing almost any piece of copper scrap can be used to produce a copper metal that is physically equivalent to the corresponding product made from virgin copper concentrates. Only cost considerations constrain the amount of scrap used by the primary producers, and for that reason we would expect the demand from this source to be quite responsive to market prices.

III. PRIMARY COPPER PRODUCTION

Primary copper is obtained from open pit mines, deep mines, and through the leaching of low grade waste materials. Copper ores are pulverized and then concentrated through differential flotation. Concentrates are smelted to remove sulfur and volatile impurities such as antimony, arsenic, and bismuth. Although copper concentrates are the principal input to the smelters of the primary producers, large quantities of scrap copper are also used as a feed stock. Blister copper produced by these smelters is then refined by fire or electrolysis and cast into refinery shapes and shipped to brass mills, wire mills and other fabricators.

Virgin and scrap copper substitute in several places. The first is where low grade scrap is used along with copper concentrates as an input to primary smelters. Higher grade scrap is processed by secondary smelters to produce an output which subtitutes for blister copper as a refinery input. High grade scrap, much of it obtained as an industrial by-product of manufacturing operations, is melted and fabricated into ingots which can substitute for refined primary copper. Finally, the highest quality prompt scrap substitutes for primary ingots as an input to the brass industry. Much of this latter scrap is captive in that the fabricating operations where it is generated are owned or controlled by the primary producers which also happen to own brass mills. This scrap is automatically recycled regardless of market prices.

IV. MODEL SPECIFICATION

Our narrative description of the copper industry suggests that the industry is conveniently disaggregated into a primary sector, a secondary sector supplying new (prompt) scrap, and a secondary sector supplying old (obsolete) scrap. An annual model of the domestic copper industry, formulated along these lines has been estimated by Fisher et. al.[6] Independent of this work we used monthly data to model a number of the processes where primary and secondary copper substitute for one another. We found it impossible, in general, to specify an identified demand curve, and therefore, were restricted to the estimation of supply equations alone. The estimated supply elasticities using monthly data were somewhat higher than the long-run supply elasticities estimated by Fisher. The probable cause of this disparity is that deviations in prices from their expected value induce fairly large short-run increases in quantity supplied as speculative inventories adjust. In the long run the responses may be more muted. A depletion of the accumulated reservoir of available scrap due to high prices in the present period of would lead, other things equal, to lower collections of scrap in the future. Thus the long run response to a permanent upward shift in price may be considerably less than the short run impact.

Fisher's econometric model of the domestic copper market is especially valuable to us in that it provides estimates of supply and demand elasticities for primary copper, as well as the supply elasticity for secondary copper, all three elasticities being necessary for the evaluation of tax induced shifts in supply curves on market price. Additionally, the Fisher approach can be viewed as providing long-run parameter estimates, a feature which is certainly open to doubt in a monthly model.

The supply of primary copper was modeled by Fisher as a distributed lag over past copper prices. The basic stock adjustment model described in Chapter 10 was used to model the supply of primary copper. U.S. mine production in thousands of metric tons, Q_t, was regressed on the price of copper, P_t, and lagged mine output. Prices were obtained from the Engineering and Mining Journal (computed by the EMJ as .975 times the U.S. producer price plus .025 times the London Metal Exchange price), and then divided by the wholesale price index (1967 = 100) and expressed in dollars per metric ton. The primary supply equation was estimated by two steps least squares with an autoregressive correction for serial correlation.

$$Q_t = -160.04 + \underset{(2.99)}{14.27\ P_t} + \underset{(3.55)}{0.726\ Q_{t-1}} \qquad (24)$$

$p = 0.5$ Years: 1949-1958, 1962-1966

The years 1959-1961 and those following 1966 were deleted to eliminate the effects of major copper strikes in 1959 and 1967-1968. Denoting the current period estimated response as the short run and the final equilibrium response as the long-run, short-run supply elasticity is .45 and in the long-run 1.67.

Obsolete and prompt copper scrap are generated by two fundamentally different processes. Because scrap copper statistics report old and new scrap separately, it was feasible to estimate separate supply equations for each sector.

For obsolete scrap the supply equation should reflect the impacts of both availability and price on quantities supplied. Availability equals cumulative production plus net imports, less removals for recycling and natural decay of the material over time. Fisher estimated a cumulative availability series, which he termed K_t^*, by assuming an initial stock of material available for recycling in 1948 and adjusting this stock each year to reflect production, net imports and removals for recycling. Several different values of the 1948 stock were used, but the choice of this variable had almost no impact on the estimated coefficients in the supply equation. The price for scrap copper was taken to be the London Metal Exchange price. There is a separate domestic scrap copper price; it is highly correlated with the LME price and yielded substantially the same results as those reported below. Denoting the quantity of old scrap recycled in year t in thousands of metric tons by OS_t, and the price deflated by the wholesale price index by P_t, the estimated obsolete supply was:

$$\log \frac{OS_t}{60{,}000 + K_t^*} = -9.878 - \underset{(2.96)}{.3731} \log \frac{OS_{t-1}}{60{,}000 + K_t^*} + \underset{(3.99)}{.422} \log P_t \qquad (25)$$

$\rho = 0.9$ Years: 1950-1968

The implied short-run elasticity of old scrap supply with respect to the LME price is about .43. The long-run elasticity of .32 is lower because high collections in one period reduce the quantities available for recycling in subsequent periods.

The model for new scrap production was estimated as a linear function of total copper consumption. Denoting new scrap collections in thousands of metric tons by NS_t and total consumption, also in thousands of metric tons, by C_t, the estimated supply of new scrap was:

$$NS_t = -275.2 + \underset{(7.56)}{0.3961}\, C_t \qquad (26)$$

$\rho = 0.2$ Years: 1947-1968

There was no evidence of a significant price effect on new scrap supplies.

The demand for copper was specified as a distributed lag over the EMJ price of copper, P_t, the lagged price of the substitute aluminum, ALP_{t-1}, the Federal Reserve Index of industrial production, IP_t, and the change in inventories of consumer durables, ID_t. The estimated equation was:

$$C_t = -14.75 - \underset{(7.06)}{12.37}\, P_t + \underset{(1.79)}{8.29}\, AIP_{t-1} + \underset{(5.56)}{5.08}\, IP_t + \underset{(9.43)}{60.49}\, ID_t$$

$$- \underset{(6.25)}{44.40}\, ID_{t-1} + \underset{(7.02)}{0.79}\, C_{t-1} \qquad (27)$$

$\rho = -0.8$ Years: 1950-1958, 1962-1966

At the means the short-run elasticity of copper consumption with respect to the price of copper is -.173 and the long-run elasticity if -.867.

The final equation which is necessary to close the model is the relationship describing net exports of copper from the rest of the world into the United States. Let X_t denote exports in thousands of metric tons, $LMEP_t$ the London Metal Exchange price, PP_t the domestic producer price of copper, C_t the domestic consumption of copper, Q_t mine production, and D_t a dummy for the presence or absence of export controls. The estimated net export equation was:

$$X_t = -795.5 + \underset{(2.21)}{1.397}(PP_t - LMEP_t) + \underset{(2.20)}{0.934}(C_t - Q_t) + \underset{(2.64)}{145.8}\, D_t \qquad (28)$$

$$p = -0.1 \qquad \text{Years: } 1952\text{-}1968$$

An increase in the U.S. producer price of one cent per pound with the LME price constant increases net exports by about 31 thousand metric tons. No elasticity was reported by Fisher.

V. EVALUATION OF TAX IMPACTS

In this section we use the econometric model to estimate the impact of virgin material tax preferences on incentives to recycle scrap copper products. The estimates assume the virgin copper supply curve is shifted by the full amount of the tax, that is that all taxes and subsidies are passed forward into product prices.

A five percent increase in the supply price for domestic mine production, which is about the maximum one could expect if all tax subsidies to primary producers were eliminated (see this report, p. 104), would induce increased imports into the U.S., increase old scrap collections, and reduce both the quantity of copper consumed and domestic mine production. We will compute each of these in turn.

The long-run response of mine production to a one cent per pound increase in the price of copper is about 280 thousand metric tons, whereas net imports would increase by some 31 thousand metric tons. Although imports do respond to price differentials between the London price and the domestic producer's price, the impact is small relative to the impact on mine output. Furthermore, the fact that Fisher did not present the elasticity for net imports complicates the calculation of the final equilibrium. We will ignore imports in the computation below, but it should be noted that if imports were included the estimated price impact would be diminished and the quantities of old scrap recycled would be less than those estimated in this section.

The long-run price elasticity of domestic supplies (the weighted average of elasticities of mine production, 1.67, and obsolete scrap collections, 0.32 with eights of 0.45 and 0.185 respectively--new scrap and imports accounting for remaining fraction) is about 0.81. The supply curve for final copper outputs is shifted upward by 5 percent times the share of primary copper in total industry supply (0.45), or about 2.25 percent. The equilibrium price of copper rises by a percentage equal to the amount of the supply shift multiplied by the ratio of industry supply elasticity to the sum of supply and demand elasticities, or $\Delta P/P = 2.25$ percent X $0.81/(0.876 + 0.81) = 1.08$ percent. The consumption of obsolete scrap copper would rise by the product of this price change and the scrap supply elasticity, or 0.32 X 1.08 = 0.35 percent.

CHAPTER 11

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CHAPTER 12

ALUMINUM

Aluminum ranks second by weight to steel in domestic metal output. The supply of aluminum for domestic consumption is derived from domestic bauxite production, imported bauxite ores, imports of alumina and aluminum, and recycling of scrap aluminum. In 1968 these supplies in thousands of short tons were: domestic production 418, imports of bauxite 2,748, imports of alumina 696, imports of metal 785, and secondary metal 817[1]. Exports amounted to some 808 thousand short tons of metal.

Two features distinguish aluminum from the other metals in this report. The first is the relatively small impact of percent depletion and other subsidies on the market price. As discussed in Chapter 6, percent of depletion is available on the value of bauxite produced, but bauxite costs are a small portion of the total cost of producing aluminum. The second feature distinguishing aluminum from the other metals in this study is the low percentage of obsolete aluminum that is presently recovered. In contrast to lead where obsolete scrap accounts for over four-fifths of total scrap supplied, and copper where obsolete scrap is more than one-third of total scrap supply, obsolete aluminum accounts for only about one-fifth of the aluminum scrap supply. In part this is a reflection of the relatively young age of the aluminum industry and the consequent small stock of metal available for recycling, but it also reflects a basic technological constraint that prevents recycled aluminum from attaining as high a purity as primary metal made from bauxite ores.

This chapter is divided into five components.

1) Inputs to the secondary aluminum industry
2) Outputs of the secondary aluminum industry

3) Outputs of the primary aluminum industry
4) Discussion of model specification and estimation
5) Evaluation of tax impacts

I. INPUTS TO THE SECONDARY ALUMINUM INDUSTRY

A. Obsolete Scrap

The transportation industry (principally airframe and automobile recycling) account for well over half of all obsolete aluminum that is recycled. (Battelle)[2] Other important sources include building and construction, consumer durables, electrical and, machinery and equipment. The relative importance of the various sources of aluminum scrap and the percentages of scrap generated by each source ultimately recycled are shown in Table 12-1.

Of the various sources of old scrap the automobile should contribute most to future growth in scrap availability. At present the automobile accounts for about 40 percent of the scrap originating in the transportation sector or about 25 percent of all obsolete scrap which is recycled. In the 1950's and early 1960's the typical automobile contained some 30 to 40 pounds of aluminum, but recently the use of aluminum in automobiles has increased to a range of 70 to 90 pounds. In the future as these cars are scrapped the supply of old aluminum available for recycling will be augmented substantially.

B. Prompt (New) Scrap

The aluminum industry itself and other industries that fabricate aluminum products are the principal sources of new scrap. Fabricating activities which generate the largest quantities of prompt scrap include the production of airframes, aircraft engines, automobiles, metal stampings, doors, windows, trim, and refrigeration machinery.

II. OUTPUTS OF THE SECONDARY ALUMINUM INDUSTRY

Secondary aluminum smelters are the largest intermediate consumers of aluminum scrap, purchasing approximately 70 percent of the total annual supply. (Gordon)[3] Their major product is secondary aluminum alloy ingots, made almost entirely from scrap. Most of these alloys are sold to the casting industry.

Table 12-1. OLD ALUMINUM SCRAP RECYCLING, 1969

Scrap source	Estimated aluminum becoming obsolete, tons	Estimated old aluminum recycled, tons	Estimated percent recycled	Estimated aluminum not recycled, tons
Building and construction	71,000	9,000	13.0	62,000
Transportation	329,000	100,000	30.0	229,000
Consumer durables	197,000	25,000	13.0	172,000
Electrical	7,000	6,500	93.0	500
Machinery and equipment	61,000	15,000	25.0	46,000
Containers and packaging	486,000	2,000	0.4	484,000
Other	183,000	17,500	9.2	165,500
Totals	1,334,000	175,000*	13.1	1,159,000

* Imports are ignored because it is believed that the old scrap component of imports is not significant.

Source: U.S. Bureau of Mines, Minerals Yearbook, 1969, Preprint for Aluminum, and Appendix B, Table B-1.

The casting process uses molten aluminum and is more tolerant of foreign metal contamination than either the milling or extrusion processes. Because of this, secondary smelters purchase all grades of scrap, including most of the supply of obsolete scrap. About 85 percent of the obsolete scrap that is recovered each year is consumed by secondary smelters, this source of supply accounting for about 15 percent of their inputs.

Nonintegrated fabricators can act as intermediate consumers or final consumers. As intermediate consumers they purchase about 18 percent of the total scrap supply. Nonintegrated fabricators are aluminum fabricators that do not have primary aluminum reduction capabilities. Because they must obtain all of their aluminum requirements from outside sources, the availability of scrap is important to them. Secondary aluminum use is possible for nonintegrated fabricators because many of them specialize in extrusion processes which are intermediate between casting and milling processes in tolerance for secondary alloying metals. Still this scrap must be of the highest quality, and as a result, virtually all of the secondary aluminum purchased by this sector is prompt industrial scrap.

Primary producers consume the remaining 12 percent of the scrap supply, a small percentage of which is obsolete scrap.

Ultimate consumers of secondary aluminum include rolling mills, nonintegrated fabricators specializing in extrusion processes, foundries, and plants which manufacture aluminum products for deoxidizing steel and other chemical processes.

Rolling mills are dependent on primary aluminum ingot as an input. The rolling mill process requires that cold aluminum be squeezed by rollers producing items such as sheet, plate, and pipe. To provide suitable feedstock for rolling mills the cold aluminum ingot must be high in purity and contain very low percentages of alloying agents. Because it is difficult and economically infeasible to remove metallic contaminants and alloy constituents from aluminum scrap by the usual melting and refining processes, only small quantities of the most pure secondary aluminum go to rolling mills.

For the most part, extrusions require the use of the more pure primary ingots. This market can tolerate the use of some secondary alloy ingots, but they must be made from the most select, clean scrap. The use of obsolete scrap by this sector is almost nil.

Foundries produce casting alloys which are used in die, permanent mold, and sand casting. The specifications for many of the casting alloys permit more than trace amounts of iron, zinc, and manganese. This, then, is the major market for secondary alloy ingot produced by secondary smelters. Many of the castings are prepared from obsolete and prompt scrap that has not been highly segregated.

Although two ingot alloys prepared to specification for consumption by the foundries by either a primary producer or a secondary smelter are completely substitutable, alloy ingots produced by secondary smelters usually are purchased because they are less expensive. Primary producers have been competing in the castings alloy market since 1950 by selling molten aluminum to major customers such as automobile manufacturers at special prices under long term contracts. The automobile manufacturers cast the molten aluminum into the necessary parts at their own plants. The discount offered by the primary producers for this form of delivery ranged up to 15 percent of the list price of 99.37 percent pure aluminum. In an industry where there is typically about a three cent difference in price between primary and scrap aluminum, this discounting garnered a substantial share of the castings market for primary producers. Apparently, despite hearings in the late 1950's by the House of Representatives' Small Business Committee, there has been no action to prohibit these contracts. Recently, large secondary smelters have entered the molten aluminum market, further intensifying competition between primary and secondary metal, but also returning secondary aluminum to the position of dominance it once held.

The importance of the castings industry to the producers of secondary aluminum suggests that the future of aluminum recycling may be closely tied to the future performance of the castings industry. Of 1969 castings shipments, die castings accounted for 60.5 percent, permanent mold castings represented 25.6 percent, and sand castings made up 13.0 percent. The major die castings market is the automobile industry. The correlation between swings in automobile production and the production of secondary aluminum derived from obsolete scrap appears to be high, judging by casual inspection of the two series. The amount of obsolete scrap that will be recycled may be constrained by the performance of the castings industry, particularly the market for automotive castings.

Plants which manufacture deoxidizing chemicals consume about 50,000 tons of aluminum annually. Low purity aluminum can be used for the production of these chemicals. Secondary smelters presently have approximately 60 percent of this market. Although this is an area of open competition between primary and secondary aluminum, the market is too small to contribute significantly to the demand for obsolete scrap. The same is true of the demand for other products using aluminum, such as aluminum chloride, pyrotechnics, explosives, and exothermics.

III. MODEL SPECIFICATION AND ESTIMATION

This section reviews the system of linkages between shifts in virgin material supply curves and the use of scrap materials. The key relationships are then estimated through the statistical analysis of time series data.

A change in the tax status of inputs to the primary aluminum industry first induces a shift in the industry supply curve. The shift in supply translates into a change in the equilibrium price of primary aluminum at all stages in its manufacture. Certain of the intermediate and final products of the primary aluminum industry compete with the corresponding products of the secondary aluminum industry as inputs to other production processes and as items of final consumption. These points of substitution must be identified and the impact of changes in the price of primary-based products on the use of secondary aluminum outputs must be estimated.

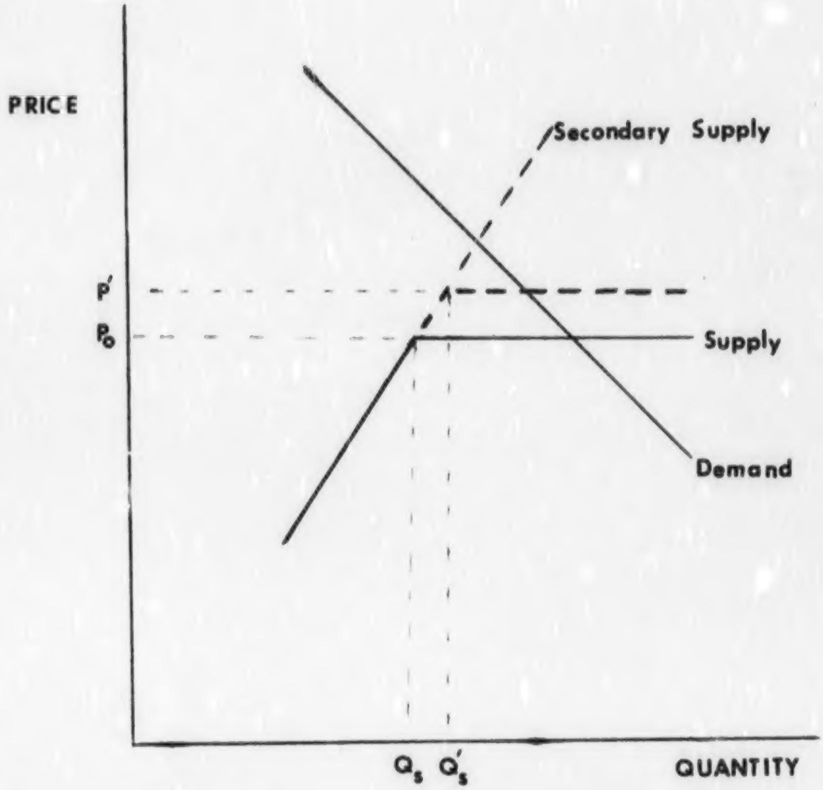
The relative abundance of high-grade bauxite deposits in the earth's crust suggests that the long-run supply curve of primary aluminum is probably highly elastic. In fact when Charles River Associates[4] modeled primary aluminum supply they explained price in terms of production costs, implicitly assuming the own price elasticity of supply was infinite. Under this assumption the demand elasticity for all aluminum outputs is irrelevant for purposes of computing price effects of tax subsidies. An increase in the cost of producing primary aluminum, attributable to the elimination of subsidies such as percent depletion, would increase the long-run primary aluminum price per pound by approximately the amount of the subsidy per pound produced. The approximation that market prices increase by the amount of the shift in supply overstates the change in market price to the extent supply is less than infinitely elastic. The amount of the overstatement could be quite large in view of the elastic nature of primary aluminum demand (estimated at -3.35 by Charles River Associates, p. 6-66). If the supply elasticity was +3.35 rather than infinite, the impact on price of a unit shift in supply would be halved.

Industries which use both secondary and primary aluminum as inputs may be viewed as facing a kinked supply curve for inputs. Below the market price of primary aluminum they face the supply curve of secondary aluminum. The input supply curve becomes elastic at the market price of primary aluminum. This suggests that the input demand curve intersects the supply curve to the right of the kink at Po. (See Figure 12-1)

Should the market price of primary aluminum rise the new input supply curve would follow the supply of secondary aluminum up to the new equilibrium

FIGURE 12-1

INPUTS TO CASTINGS AND EXTRUSION INDUSTRIES



price of primary aluminum and become elastic at that point. The quantity of secondary aluminum consumed would rise from Qs to Qs' subject to the constraint that Qs' not exceed demand at P'. We will not attempt to estimate the demand curve for inputs to the castings, extrusion, and chemical industries which process aluminum into final products, but rather assume that this constraint is not binding given that the change from Qs to Qs' represents a small (less than 10 percent) increase in secondary use relative to the quantity of primary aluminum used in each of these industries. The constraint would be binding only if the demand curve was highly elastic.

The elasticity of the supply curve for secondary aluminum is the one remaining unknown required to estimate the impact of tax subsidies to primary producers on the quantity of scrap recycled in the model we have just outlined. We will assume that as the production of castings and the like varies over time the demand for primary and secondary aluminum inputs fluctuates about a relatively fixed supply curve. The points of equilibrium between demand and supply will trace out the supply curve. Again referring to Figure 12-1, equilibrium pairs such as Po, Qs will be points on the supply curve for secondary aluminum.

We attempted to estimate this supply curve from monthly time series data. Theoretically it should make no difference whether prices for primary or secondary aluminum ingot are used. In equilibrium these two prices should converge. In fact, however published prices are not the same for primary and secondary aluminum. The usual explanation for this is that the quoted price for primary aluminum does not represent the price at which primary ingot is actually traded. Rather the published price serves as a benchmark from which primary producers offer discounts. Conveniently for our purposes the discounted or real transactions price for primary ingot is thought to be accurately represented by the price of secondary aluminum. (CRA) The price used in the supply equation was the price of #12 Secondary Alloy Ingot.

For quantity we used net metallic recovery from aluminum scrap and sweated pig consumed at secondary smelters. This quantity includes 100 percent of aluminum recovered from old scrap plus a small percentage of recovery from new scrap. Most new scrap is consumed in the primary sector with only small amounts consumed at secondary smelters.

The supply equation was estimated by two stage least squares using as instruments lagged price, lagged quantity, and the Federal Reserve Index of automobile production. Secondary supply was estimated as:

$$Q_t = 5.8 + \underset{(1.42)}{1.44P_t}$$

Years: 1962-1972

Although price has the correct sign in the supply equation, it is marginally significant as best. Consequently, the estimated short-run price elasticity of .86 must be interpreted with caution. Because the elasticity exceeds that found for the long-run supply of scrap copper and scrap lead, we are inclined to believe the estimate for aluminum errs on the high side.

In Chapter 6 it was predicted that elimination of percent depletion for aluminum would elicit at most a two percent increase in the price of primary aluminum. According to our estimate of the secondary supply elasticity such a price change would increase the quantity of aluminum recycled by 2% x 0.86 = 1.7%.

CHAPTER 12

REFERENCES

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3. Gordon, R. Effective Systems of Scrap Utilization: Copper, Aluminum, and Nickel. U.S. Bureau of Mines. 1972.
4. An Econometric Analysis of the Aluminum Industry. Charles River Associates. NTIS, 1971. PB-199 789.

CHAPTER 13
SUMMARY

This report consisted of two major sections: the first in Chapters 2 through 6 contained an analysis of governmental tax policies and how they affect the supply of virgin raw materials; the second in Chapters 7 though 12 analyzed the impact of tax policies on the recycling of various materials. We met with varying levels of success in completing the two segments of the project.

Estimates of the impacts of tax subsidies on material supply can be based on a rigorous theoretical foundation. For the depletion allowance, which may be viewed as a negative excise tax on output, supply is shifted by the amount of the subsidy. Preferential taxation of capital gains probably should be viewed as a subsidy to capital as a factor of production. To estimate the shift in supply resulting from the preferential taxation of a single factor would require knowledge of the elasticity of substitution in production and the supply elasticities for inputs. These parameters are not well known for the timber industry. In this situation we used the combination of assumptions which would yield the maximum impact on supply. Consequently, the figures for the timber industry may overestimate the long-run impact of capital gains taxation on timber supply. Tabulated below are the upper limits effects of tax subsidies on the supply curve for five virgin materials.

Similar estimates were made in a 1974 study conducted by Booz, Allen and Hamilton.[1] In that study the impacts on virgin material supply curves were interpreted as price impacts. This interpretation would be valid only in the case where virgin material supply curves are infinitely elastic. The available evidence on this subject (see the sections on lead and copper for examples) does not support this assumption; supply curves appear to have an elasticity between one and two. This indicates that the price impacts computed in the Booz, Allen and Hamilton report are overstated by a factor of about two.

Table 13-1. IMPACTS OF TAX SUBSIDIES ON VIRGIN MATERIAL SUPPLY CURVES

	Maximum possible impact	Likely impact
Steel	3.0%	2.0%
Paper	4.2%	1.0%
Lead	3.0%	
Copper	6.0%	5.0%
Aluminum	2.2%	

Both the Booz, Allen and Hamilton report and the present study tried to assess the impacts of virgin material tax subsidies on the flow of recycled materials. As noted in the introduction, the Booz, Allen and Hamilton report relied on interviews with industry executives to assess the impacts of tax subsidies on the flow of recycled materials. This approach met with little success and pointed out the need for the development of econometric models of primary and secondary materials flows.

The present study based the econometric approach on the analysis of primary and secondary material flows. Five pathways were identified where significant substitution of the two materials occurs. An econometric model of supply and demand was specified and estimated for the pathway of most extensive substitution in each industry. The following paragraphs develop a general model of scrap markets with special reference to the wastepaper and scrap steel industries.

For both wastepaper and scrap steel the most significant substitution of secondary for primary materials occurs in the primary processing sectors. This suggests that important determinants of demand include (1) A, the level of activity in the manufacturing industries which consume scrap inputs, (2) P, the price of secondary materials, (3) V, the price of competing virgin-based inputs, and (4) T, the technology of material processing. Representing the quantity demanded in period t by Q_t, we have:

$$Q_t = a + bA_t + cP_t + dV_t + fT_t + e_t \qquad (1)$$

where e is a random variable with mean zero.

Reported quantity data include two components of supply: prompy scrap and post-consumer scrap. The supply of prompt scrap is easily represented as a function of current or recent levels of activity in primary manufacturing operation, but the supply of post-consumer scrap is far more difficult to model adequately. We assumed that X_t, the supply of obsolete scrap in period t, is a function of the price of scrap, P_t, and the availability of scrap material, K_t, and the technology of scrap recovery R_t. That is:

$$X_t = g + jP_t + jK_t + kR_t + v_t \qquad (2)$$

The linear additive form for this relationship was based on the assumption that within the range covered by the data, the effect of price on quantity is approximately independent of the availability of scrap or the technology of scrap recovery. We did not expect this assumption to hold precisely, but it facilitates estimation of a supply equation from existing data. By availability is meant the relative ease with which additional units of scrap can be recovered from the environment. This depends upon the absolute size of the reservoir of post-consumer scrap as well as the extent to which the readily recoverable scrap has been retrieved in recent periods. More formally, availability may be approximated as:

$$K_t = mP_{t-j}Y_t \qquad (3)$$

where Y is the stock of consumer and capital goods containing the material of interst, and lagged price, P_{t-j}, reflects the extent of previous scavanging efforts. The higher was price j periods ago, the lower is availability today.

Changes in the stock of material from which obsolete scrap is derived in turn depend upon the output of final consumption goods made of the material, the removal of obsolete scrap from this reservoir, and the physical decay of the stock (e.g., rusting). Therefore:

$$Y_t = A_t - X_t - \lambda Y_{t-1} \qquad (4)$$

where all variables are as defined previously and λ is the rate of physical decay.

The final supply equation is obtained by combining (2) and (3) and adding a prompt supply component, A_{t-i}.

$$Q_t = g + hP_t + rP_{t-j}Y_t + kR_t + nA_{t-i} + v_t \qquad (5)$$

Data on Y_t, are not reported. In principle, such a series could be generated from existing series and the posited relationship in (4). In practice, we were unable to obtain satisfactory measures of the rate of decay and resorted to the assumption that the stock was constant over the period covered by the data (approximately 12 years for both paper and steel). The final specification of demand is (1) and of supply is (5) with the multiplicative term Y_t dropped.

At least two considerations remained before we were able to proceed with statistical estimation of demand and supply. One consideration was the frequency of observation, in particular whether to use monthly or annual data. The second consideration concerned data reliability and this was discussed at length in the report.

Reviewing demand (1) and supply (5) one notes that lagged values of many or the determinants of demand are also determinants of supply (e.g. price and primary processing activity). Discussions with industry representatives and a brief review of the trade literature suggested that the lag in both cases is fairly short - on the order of a few months at most. If the equations are estimated with annual data one must choose some linear combination of current and one-year-lagged values of price and industrial activity for the supply equation. Because current price already appears in the supply equation, this procedure will certainly introduce multicollinearity to supply. Furthermore, the fact that so many of the same variables appear in both the supply and demand equations introduces the risk that neither equation will be identified - particularly if technology cannot be accurately measured and virgin and input prices are unreliable as indicators of true input costs. This suggests that identification of the equations and estimation of separate parameters would be more likely to succeed with monthly observation intervals. Also, we might add, many of the reported quantity series were consistent for relatively short periods. However difficult this factor makes the compilation of reliable monthly time series, it renders nearly impossible the construction of consistent annual data series of reasonable length for many variables. Again we conclude that monthly data are more appropriate.

The frequency of the data intervals bears no necessary connection to the interpretation of parameters in the equations as short-run or long-run. For example, cross sectional relationships are frequently interpreted as long-run, even though all observations occur at one point in time. In comparing monthly with annual models the designation short-run would best be applied to the model which is designed to capture equilibrium relationships. Typically, long-run models use distributed lags to capture the ultimate impacts of changes in the independent variables. The models used in this study were not designed to capture all long-run impacts (e.g. investment effects), but do represent our efforts to measure equilibrium responses as constrained by existing plant and technology.

Accuracy of price data is another problem confronting those who would develop econometric models of secondary material markets. Secondary material prices are assumed to be generated in competitive markets and to be reported without bias. However, the accuracy of the published prices of virgin materials which substitute for scrap steel and wastepaper was questioned in the separate chapters on each product. These prices are posted by oligopolistic industries and may not represent actual transaction prices. Furthermore, because less then 10 percent of the product is actually sold, the remainder being consumed internally by vertically integrated producers, the price may bear little or no relationship to the costs of production. These measurement errors have important implications for the estimated demand equations because measurement errors in variables will bias regression coefficients toward zero.

The fact that the cross elasticity of demand for scrap with respect to the price of the competing virgin based input is biased toward zero in this specification dictates that we consider alternative demand specifications that do not have this bias. One such possibility is to assume that secondary and primary inputs are perfect substitutes and that the quantity of secondary material purchased is small enough relative to total demands that the own price elasticity may be taken as infinite (as in Figure 12-1). A second such alternative is to assume an infinite cross elasticity and estimate the combined input demand curve (as in Figure 10-1). The first approach may be appropriate for aluminum and paper, where about one-fifth of all inputs are derived from secondary materials, but it clearly would not hold for lead or scrap steel, where half of the metallic inputs come from secondary sources. The second alternative appears especially appropriate for lead, copper, and to a lesser extent, steel, where outputs of the primary and secondary sectors are virtually indistinguishable and substitute freely in a wide variety of industrial applications. Table 13-2 contains a summary of the estimated impacts of virgin material tax subsidies on the quantity of secondary materials recycled. All figures are based on maximum price effects from Table 13-1, and are expressed as a percentage of the quantity of secondary materials currently recycled.

Table 13-2

RECYCLING IMPACTS OF TAX SUBSIDIES TO VIRGIN PRODUCERS UNDER ALTERNATIVE DEMAND SPECIFICATIONS

Secondary material	Demand dependent on virgin and scrap prices	Demand elastic w.r.t. all prices	Combined input demand curve estimated
Scrap steel	0.37%*		
Wastepaper	0.04%	0.67%	
Lead			0.09%
Copper			0.61%
Aluminum		1.7%	

* The impact on obsolete scrap may be twice this large - if prompt scrap supply is independent of price.

Although the indicated near-term impacts of tax subsidies to virgin material industries are modest, these subsidies distort long-term investment decisions toward that sector. As noted in Chapter 6 these investment decisions lower the total output of goods and services produced in the economy. The relatively low recycling responses which could be expected to follow the elimination of virgin material tax subsidies could be attributable, in part, to the investment distorting impacts of the subsidies (e.g. locating paper plants near pulp wood supplies).

Tax subsidies to virgin material production are only one aspect of existing federal policies which adversely affect the flow of recycled materials. As noted in the introduction, these other policies include freight rate discrimination, labeling requirements for scrap-based products, mining laws which give away valuable mining rights, a failure to price residential solid waste disposal, and in other ways pricing materials at less than their full social cost. Although the impacts of virgin material tax subsidies appear to be modest (within existing technologies and capital stock), the cumulative long-run impact of all federal policies which affect material use may be to reduce significantly the flow of recycled materials.

The use of these econometric models of materials flows is not limited to the analysis of virgin material tax subsidies. Also within the realm of analysis are tax subsidies to producers and consumers of secondary materials as proposed in H.R. 148 and H.R. 9467. The impacts of other market parameters can be assessed to the extent they can be translated into price changes. For example, the impact of differential freight rates on recycling is easy to measure once the differentials have been estimated.

An alternative federal recycling policy, which has received increasing attention in Congress, is the direct subsidization of secondary suppliers or users. Under S. 148, for example, suppliers of scrap iron and steel would be granted a 15 percent depletion deduction and those supplying wastepaper would receive an 18 percent depletion deduction. Assuming corporate income taxation at a 48 percent rate and a profit margin of at least the same percentage as the depletion deductions, the price at which scrap steel could be sold would be lowered by 0.48 x 0.15 = 7.2% and that for wastepaper by 8.6 percent. Using the demand and supply elasticities estimated previously, the impact on the quantity of steel recycled would be 2.9 percent and for paper 0.69 percent.

The cost to the government in terms of lost tax revenues should also be calculated if one is to evaluate the merits of depletion deductions to scrap processors. The depletion deduction would apply to every unit of scrap recovered. Its total magnitude may be calculated as: tax rate times the lesser of profit rates or depletion rates times price times quantity.

The impact on quantity is as stated above (reduced by the percentage by which profit rates fall short of allowed depletion rates). For scrap iron and steel the cost per incremental unit recovered would be (7.2)/2.9 = 2.5 times market price, and for wastepaper the cost per additional unit recovered would be (8.6)/(0.69) = 12.5 times current market price. One could question whether the social costs of unrecovered scrap exceed the private costs of this scrap by a multiple of several times market value. If social costs fail to exceed private costs by this margin there is no economic justification for this piece of legislation.

Another form of tax subsidies is a direct cash payment to scrap users. The $10 per ton credit to users of wastepaper contained in H.R. 9467 would shift demand upward by the amount of the subsidy. Using the parameters of the wastepaper model estimated in this paper it can be shown that quantity would increase by 2.4 percent. The cost to the Treasury would amount to 12.5 times the assumed market price of $30 per ton. Again one must assume very large social costs from unrecovered wastepaper to justify such a subsidy.

Several improvements in and extensions to this work can be suggested. First, more effort could be devoted to the analysis of the elasticities of substitution and input supply for virgin material production so that the exact impact of tax subsidies could be derived. A second area of further inquiry would be the completion of some of the econometric models, particularly that of wastepaper, steel, and auminum. For wastepaper, an equation explaining the inventory behavior of scrap dealers would be useful in understanding supply response and market fluctuations. For scrap steel, both an inventory equation and an export equation would be desirable additions to the model. In the case of aluminum a demand equation for secondary metal would be desirable. For steel, wastepaper, and aluminum it would also be useful to attempt to estimate a combined input demand curve, under the assumption that primary and secondary inputs are perfect substitutes in the long-run. A final suggestion for further research concerns the impact of tax subsidies on investment decisions. Clearly, this is an important question. It is our feeling, however, that both the state of the economic theory of investment and the data which are available may be inadequate foundations for such a study at this time.

CHAPTER 13

REFERENCE

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APPENDIX

MINERAL DEPLETION ALLOWANCES

Section 613 of the Internal Revenue Code specifies percentages of "gross income" allowable as a deduction to a maximum of 50% of a taxpayer's "taxable income from mineral producing property". Percentages ranging from 5% to 22% are listed for every mineral but "soil, sod, dirt, turf, water, mosses, or minerals from sea water, the air, or similar inexhaustible sources." Each of the quoted phrases has a significant legal history and will be discussed below. However, the basic concept behind the depletion deduction is rather simple:

> "The statutory concept of taxable income, developed since the adoption of the Sixteenth Amendment, involves the allowance of some deduction based on the theory that production of income may necessitate exhaustion of capital assets employed in that production...The purpose of the depletion deduction is to permit the owner of a capital interest in mineral in place to make a tax-free recovery of that depleting capital asset."[1]

LEGISLATIVE HISTORY

While the theory behind depletion is simple, its actual development has been complex. Despite repeated attacks, depletion provisions were routinely broadened in scope until 1969. The Treasury Department calculated that the excess of percentage over cost depletion* provided a net benefit to mineral industries of almost a billion dollars in 1971.[2] When first enacted in 1926, percentage depletion was much less significant; the mineral industry was much smaller and corporate taxes took 13.75 cents per dollar of corporate profits instead of 48 cents. But while our economy has changed, the justification for allowing specific rates of percentage depletion has never been subjected to thorough Congressional analysis.

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*"Cost depletion" is based upon the actual cost of a deposit to the taxpayer and is similar to the depreciation allowed other industries. Under this method, the taxpayer can usually not deduct more than the actual amount spent on a capital investment, whereas percentage depletion is based on a percentage of gross income and often greatly exceeds actual expenditures. This excess of deductions over expenditures is often the focus of criticism by opponents of depletion allowances.[3]

The first corporate tax, passed in 1909, made no provision for depletion. The Treasury Department developed regulations for it but never put them into effect. The 1913 Act, passed after the 16th Amendment eliminated constitutional barriers to income taxes, included some recognition of the wasting nature of mineral reserves. Taxpayers were allowed to deduct:

> "...a reasonable allowance for the exhaustion, wear and tear of property arising out of its use or employment in the business, not to exceed, in the case of mines, 5 per centum of the gross value at the mine of the output for the year for which the computation is made."

This allowance has been described as "essentially a cost depletion type of calculation,"[4] but more than simple cost depreciation was possible since "gross value at the mine" was interpreted to mean market value as reflected by actual sales. (Merten's,[1] pp. 13-14) In practice, deductions may have been limited to actual capital investment. (The author was unable to discover whether or not the deduction was in fact limited as described. However, given a provision to that effect in the 1916 Act, it seems likely that the 1913 law was equally restrictive. This is Lerner's interpretation - p. 77. See also pp. 24-25.[4])

The 1916 Act introduced use of the term "depletion" and explicitly limited the total allowance to the amount of the capital investment of 1913 value in the case of investments prior to that date. The law specified that the depletion deduction was "not to exceed the market value in the mine of the product thereof, which has been mined and sold during the year for which the return and computation are made...." This provision amounted to a form of accelerated depreciation, since total deductions could be used up well before the mine had ceased to produce. Although not overly generous by today's standards, this provision did come under some attack. One ardent proponent of percentage depletion reportedly called the 1916 law "too generous to be just." (L.C. Gratton, quoted by Lerner,[4] p. 78). However, total deductions could not have been very large since corporate income tax rates were only 2%.

The first major innovation in the tax treatment of minerals came in the Revenue Act of 1918. A new concept was introduced, "discovery depletion", which allowed deductions in excess of actual investment or 1913 value:

> "...in the case of mines...not acquired as the result of purchase of a proven tract or lease, where the fair market value of the property is materially disproportionate to the cost, the depletion allowance shall be based upon the fair market value of the property at the date of the discovery, or within thirty days thereafter;"

Under this provision, "discovery value" determined the amount of allowable depletion deductions. Because this change was such a significant departure from past practices, the legislative history will be discussed in some detail.[4] [5] [6] [7]

The bill that emerged from the House Ways and Means Committee would not have made any fundamental changes in the tax treatment of minerals. On the House floor two representatives, Chandler of Oklahoma and White of Ohio, proposed more accelerated depletion as a way of encouraging exploration for minerals. There was some concern expressed regarding incentives for prospecting because of higher wartime tax rates (12% on corporations, 6% to 77% for individuals, and a surtax and excess profits tax were included in the Revenue Act.)

The concept of discovery depletion was introduced in the Senate Finance Committee. According to an Interior Department Study, the star witness before the Committee was Mark Requa, a petroleum engineer with a background in developing statistical methods for estimating oil reserves. "Having considerable confidence in the ability of engineers to estimate reserves, he did not hesitate to assure the Senate Finance Committee that the engineering aspects of evaluating mineral deposits would be a relatively routine matter." (See Lerner[4], page 80.) The Committee apparently had even more faith in the idea than Mr. Requa; he suggested allowing a year for evaluating discovery value, but the bill required valuation within 30 days.

The Committee Report did not specifically explain the reasons for adopting the discovery value approach. The "increased depletion allowance", along with a smaller surtax and excess profits tax on the sale of mines, was justified by the need to "stimulate prospecting and exploration" and in recognition of the "many years and much money" frequently spent "in fruitless search."[6] (page 418) Senator Penrose gave a more detailed explanation on the Senate floor:

> "The committee gave very careful consideration to the question of depletion...part of what apparently is income from mines is in reality a mere return of the capital of the enterprise. When, for example, a ton of coal is sold the excess of what is received from the cost of mining of that ton of coal is by no means all income; part of that excess must be treated as a repayment of what was invested in the mine from which the coal was taken.... In pursuance of a policy permitting the development of new resources of this character they also provide for a more liberal allowance than heretofore permitted in the case of newly discovered mines, permitting the deduction to be based on the fair-market value of property discovered instead of its cost."

In addition to providing an incentive for exploration, Congress was also motivated by a desire to accord the same tax benefits to discoveries "aiding the war effort" that were given to pre-1913 mine openings. The 1916 law included a provision exempting value accrued before 1913 from taxation. This was felt necessary to eliminate the unfairness of taxing profits earned but not realized before 1913, when similarly situated persons who had 'cashed in' their investments before 1913 had paid no tax. However, patriotic fervor could not have been a major reason for adopting the discovery method because the war was over and the Armistice signed before the law was passed. (Lerner viewed this historical development as cutting both ways, i.e., as indicating that perhaps the reasons for discovery depletion no longer existed when the bill was finally passed -[p. 8.] Agria[8] emphasizes the "patriotism" factor as an important reason for the bill's passage.)

The change to discovery depletion was not without its critics. Senator LaFollette and Congressman Kitchin, the latter Chairman of the Ways and

Means Committee, both attacked the allowance as unjustified special favoritism.[7]

When discovery depletion was adopted, there was little concern that deductions would be used to offset income from other sources. However, in 1921 the price of minerals declined and deductions based on earlier, higher values were excessive. The Treasury Department suggested that the deduction be limited to 50% of the income from the property. The Senate Finance Committee imposed a limit of 100% instead, with the following explanation:[6] (page 418)

> "...in order to make certain that the depletion deduction when based upon discovery value shall not be permitted to offset or cancel profits derived from a separate and distinct line of business, it is provided that the depletion allowance based on discovery value shall not exceed the net income from the property upon which the discovery is made..."

Three years later the Treasury Department's suggestion was accepted and the limit was reduced to 50%, a provision that was continued under percentage depletion and still exists.

Percentage depletion was first adopted in the Internal Revenue Act of 1926, but only for the oil and gas industry. Mr. Requa's assurances notwithstanding, by the early 1920's there was growing dissatisfaction with the operation of discovery depletion. A Senate Select Committee on the Investigation of the Bureau of Internal Revenue, chaired by Senator Couzens, was created in 1924. The Committee concentrated on the administration of discovery depletion, a focus probably due to Senator Couzens' suspicion of Secretary of the Treasury Mellon, who had major interests in petroleum and sulfur.

The Committee readily found that the administration of discovery depletion was a disaster. According to Lerner[4], (pp. 83-84)

> "The investigation clearly established that the valuation of mineral deposits, the definition of discovery, and all other facets of discovery depletion were highly arbitrary and extremely difficult to administer. It was brought out

> in the course of the investigation that in the oil and gas industry and in the case of sulfur it had become almost impossible for any oil well not to be deemed a discovery property...the Committee concluded that the Bureau of Internal Revenue had been overly generous in both the assessments of discovery values and in its definition of 'discoveries.'"

Because valuation was so difficult, rulings were being done on an ad hoc basis that favored large operators who could afford expensive legal fees. The Committee even found one case where the same property was evaluated differently for partners holding the same interests. (Lerner[4], p. 33.)

In fairness to the Bureau of Internal Revenue, the administration of discovery depletion was probably an impossible task. Value could not be easily established and provisions for taxpayer appeals sometimes resulted in several years delay when the lawmakers had envisioned a simple 30 day process. Even when done responsibly, valuation naturally aroused great suspicion when poorly understood geological methods were applied to neighboring properties and the outcome was significantly different. Moreover, the methods used depended heavily on subjective judgments of the evaluating engineer, introducing another source of inconsistency. (See Agria[8], pp. 80-81.)

The Couzens Committee, having thoroughly documented the abuses of discovery depletion, urged the adoption of a more easily administered system. The Committee recommended that actual profits be discounted back to the discovery date to determine annual depletion allowances.[8] Selections from the Senate debate (below) indicate Senator Couzens actively opposed any special depletion allowance for minerals. However, the Committee's proposal was not adopted by either the House or Senate.

The House Committee on Ways and Means relied principally on representatives of the Treasury Department in their search for ways to improve the administration of depletion allowances. A.W. Gregg, Solicitor of Internal

Revenue, asked that Congress statutorily define the area encompassed by a well.[9] This proposal was modeled after Treasury Department regulations which created a rebuttable presumption that the range of an oil well discovery was 160 acres; any one claiming another "discovery" within that area had to prove he was not tapping the same reserve. The House accepted this proposal, restricting the availability of depletion as a way of making it easier to administer.

Some strong feelings in favor of eliminating depletion allowances were also expressed during the Ways and Means Committee hearings. Representative Doughton, the Committee Chairman, asked Gregg if the Treasury Department had considered doing away with discovery depletion entirely, indicating his own support for such a proposal. (p. 163)[9]

> "If I had my way I would cut out this discovery depletion entirely. I consider that it might have been justified in time of war, and that the only justification given for it to begin with - for the purpose of inducing men to go ahead and make these discoveries. At the time we put that in, as I recollect it, it was practically admitted that in normal times they would not be entitled to anything of that kind."

Gregg replied that the Department had not gone into the question, having assumed that since Congress had upheld the idea in three acts that the issue would not arise. The same question was asked of Thomas Adams, a professor of political economy at Yale but formerly of the Treasury Department. Adams' response became a standard criticism of depletion allowances:

> "I think a great mistake was made when (discovery depletion) was authorized. I think it is bad in theory and bad in practice. But...the industry has become habituated to it. It is something like accustoming a child to some debilitating or harmful luxury and not being able to take it away from him all at once. You must legislate in view of the situation that has been created." (Hearings, p. 1006.)[9]

The proposal for percentage depletion came in the Senate Finance Committee. L.C. Manson, who had been counsel to the Couzens Committee, suggested the adoption of percentage depletion for oil and gas wells as a way of eliminating administrative arbitrariness. Starting from the same problems discussed in the House, he reached a totally different conclusion. Since everyone was getting discovery depletion anyway, he argued (Lerner found that "Every oil well, rather than oil wells in new fields, was getting the special discovery depletion allowance.")[4], a flat percentage deduction on all mineral property would be more equitable and much simpler to administer. The Committee agreed and recommended a percentage depletion allowance of 25%.

The source of the 25% figure is unclear. (This conclusion was also reached by Blaise,[6] p. 421.) However, the most likely reason was an intent to duplicate the average allowance taken under the existing discovery provision.[10] This is implied by the absence of any arguments centering on the revenue effects of switching to percentage depletion. Proponents of the change spoke only of its workability. For example, the Senate Committee Report stated, "In the interest of simplicity and certainty in administraton, your committee recommends," a 25% depletion allowance. Senator Reed made a similar statement during the floor debate: "We are trying to get away from those uncertainties and to adopt a rule of thumb which will do approximate justice to both the government and the taxpayers." Several amendments were offered seeking to raise the percentage to as high as 40% but the Senate finally settled on a 30% rate. The figure was reduced to 27½% in conference, an amount that remained in effect until 1969.

Percentage depletion was attacked in the Senate as well as in the House, particularly by Senator Couzens, whose investigation had provoked the change from discovery methods. The nature of the debates indicates that the issues were similar to those made up to the present. In response to a comment by Senator Couzens that cost depletion would be the most easily administered system, Senator Reed replied,

> "It is perfectly obvious that if I buy an acre of land in the Rocky Mountains and pay $10 an acre for it, and then, by hard work, discover a rich deposit of gold on it, the calculation of my depletion on the original $10 basis would not allow me any adequate return for my real capital...To calculate the depletion on the original cost is not fair either, because in these uncertain industries

> there is much property which is bound to be worthless, on which the taxpayer really makes a dead loss; but there is no production and consequently no depletion from that property."

The same two senators tangled over the issue of the significance of risks in the mineral industries. Senator Couzens argued that "anyone who undertakes an industry, whether it be a manufacturing industry, a bank, or something else, has an element of risk." Reed replied that in other industries "his property is generally worth something, even if the risks go against him. That is not true of the man who takes a worthless mineral claim." Couzens respectfully disagreed.

The debate does not, however, appear to have considered a key question: if discovery depletion allowances were excessive and arbitrarily determined, what sense did it make to set a rate for percentage depletion based on the allowances taken under the discovery provisions? As Lerner explains, (p. 35)[4]

> "It is difficult to see that a system of allowances based upon averaging or aggregation of allowances under the discovery method could result in a more appropriate measure of depletion. The sum of the individual errors and difficulties would not necessarily be a more satisfactory measure than the components. If anything, the types of 'errors' made in discovery depletion would more likely be cumulative since one 'error' might to some extent be a precedent for another." (See also Agria[8], p. 81.)

One additional result of the Revenue Act of 1926 evolved through regulations issued by the Treasury Department. For purposes of the 50% of net income limitation, the regulations defined "net income" so as to take into account expensed intangible drilling and development costs. This was not true under discovery depletion and in certain cases produced a significant reduction in allowable deductions. (Lerner[4], p. 90.)

EXTENSION OF PERCENTAGE DEPLETION TO METALS

Assuming administrative convenience was the primary motivation for adopting percentage depletion, it seems strange that the switch from discovery methods was at first limited to oil and gas. Two factors may provide at least a partial explanation. First, there is some evidence that oil reserves were particularly difficult to estimate. Senator Reed stated on the Senate floor:

> "We can measure the thickness of the seam of coal, we know its area, and we can calculate with considerable accuracy the tonnage that is in the ground. We do not discover oil in the same way that we discover coal. There is not the element of uncertainty about it [coal]." (Blaise[6], p. 419.)

Second, discovery depletion does not appear to have been nearly as significant for mineral industries as it was for oil and gas. Discovery depletion accounted for over 86% of the depletion taken by the petroleum industry in the early 1920's, but most metal mines were still taking depletion based on 1913 values. Far fewer mines than oil wells were the subject of applications for discovery valuation. (See Lerner[4], pp. 84-89 and Tables in Appendix C.)

However, once percentage depletion became an available alternative, the mining industry was quick to see the potential advantages. For the more commonly found minerals, particularly coal, a depletion allowance based on "discovery" was of little benefit. The process of discovery valuation was also a major expense for small operators and created some uncertainty about expected profits. Miners, too, may have foreseen the potential for depleting expenses other than the value of the mineral at the mine within the phrase "income from the property."

The National Coal Association was one of the first groups to request percentage depletion, asking for a 6% allowance in 1927. The American Mining Congress followed with a request for a 15% allowance for the mining industry. Their representative testified that discovery depletion discriminated against small operators and that percentage depletion of 15% would approximate allowances taken in the past. However, the Mining Congress proposal would have applied only to "discoveries" after the extension of percentage depletion, exhibiting a strange lack of concern for the small miner who had been deprived of depletion allowances in the past.[11] The Mining Congress submitted detailed criticism of the administration of discovery depletion in 1928, raising many of the same arguments made earlier by the petroleum industry. The mining interests had the support of Representative Arentz, who introduced an amendment during committee hearings on the 1928 Revenue Act that would have granted metal mines a depletion allowance of 16½%. Mr. Arentz stated,[12]

> "This amendment is introduced in the interest of simplification of the income tax...The outstanding advantages of the amendment are that without materially affecting the public revenue it provides a simple, equitable, and definite method of computing the depletion allowance that permits the prompt and final determination of the tax liability. It eliminates for the future the analytical appraisal of metal mines with attendant technical complexities...I have been informed by the Treasury Department that an investigation of the average depletion percentage allowed was found to be 16½% on all returns allowed during the last four or five years."

Discovery depletion continued to be a hot issue and in 1929 the staff of the Joint Committee on Internal Revenue Taxation issued a report on the tax treatment of metal mines.[13] The report criticized the Mining Congress proposals but also found discovery depletion to be neither "simple in its application nor equitable in its results," and urged the adoption of an unspecified "substitute method." The report also discussed the existing record of percentage depletion in the petroleum industry in favorable terms, noting that discovery depletion had resulted in a 53% loss of revenue in 1924, whereas percentage depletion for 1925-26 produced a loss of only 36%. (See Blaise[6], p. 411.)

The staff report also discussed the possibility of extending percentage depletion to mines. A review of the depletion allowances taken on the basis of cost, 1913 value, or discovery value in the period 1922-26 found that the average depletion allowance taken was 17.1% of gross income. The staff recommendation therefore was that if percentage depletion was adopted for metals, the applicable rate be 15%. The reason for the use of a figure less than past experience may have been to compensate for the higher allowances still being taken under 1913 valuations. L. H. Parker, Chief of the committee staff, came close to endorsing percentage depletion in his letter of transmittal accompanying the report:[14]

> "The methods of percentage depletion proposed for consideration are not such a departure from the present system as would appear from a preliminary inspection. The analytic method of valuation now used in most important cases arrives at the value through the estimation of future expected profits. Depletion based on a percentage of net income from the property merely uses actual figures instead of estimated figures."

A surprising feature of Parker's statement is his reference to calculating depletion as a percentage of net rather than gross income, the latter being the method adopted in 1926. The use of a gross income approach has been criticized for producing inconsistent results depending on the ratio of gross to net income. If the reason for depletion allowances is to encourage investment in mineral industries through higher after-tax profits, then equivalent amounts of net income should receive equivalent tax benefits.

The staff report was followed by Joint Committee hearings in 1930. Mining industry representatives spoke in favor of a depletion allowance of 33%, noting that Canada used that rate, but there was some evidence of internal dissension among corporate officials. (See Lerner[4], pp. 92-3.) A Treasury spokesman, agreed in his testimony that discovery depletion was unworkable but advocated elimination of all depletion allowances rather than adopting percentage methods. (Lerner[4], pp. 93-4.)

However, the precedent had been set and percentage depletion was extended in 1932. Sulfur producers were the first to succeed, arguing that their production processes were similar to oil and that therefore they deserved similar treatment. An amendment in their behalf was added on the House floor. The Senate Finance Committee added a new section reducing the allowance for sulfur to 23% and granting a 15% allowance to metal mines. The coal industry, which was then severely depressed, argued that it needed tax relief just as badly and was given a 5% allowance on the Senate floor. The House acceded to the Senate amendments.

While the adoption of percentage depletion for metals appears to be a significant change in retrospect, the amendments were not a significant part of the revenue act. Congressional response to the depression was the dominant issue and the key provisions were new taxes designed to balance the budget. The committee reports referred to the extension of percentage depletion as "largely administrative", and the amendments were in a section labeled "technical". A comparison of the House and Senate bills included in the conference report indicated that the "revision" in depletion was expected to add $1 million in revenue in fiscal year 1933.

Two other changes in depletion provisions were made as a result of the 1932 Act. The procedures for adjusting the taxpayer's basis in the mineral property were amended to require reduction of the basis by the amount of the deduction taken. Previously, the basis was only reduced by the amount of the deduction that would have been taken under cost depletion. (Lerner[4], p. 34.) The other change was that taxpayers reporting income from mines were required to make a binding election between percentage or cost depletion. Failure to elect meant loss of rights to percentage depletion. This provision was eliminated in 1942. (Lerner[4], pp. 95-96.)

SUBSEQUENT HEARINGS ON PERCENTAGE DEPLETION

The newly elected Roosevelt administration wasted no time in attacking percentage depletion. A 1933 statement presented to the Ways and Means Committee advocated elimination of depletion allowances:

> "Our experience shows that the percentage depletion rates set up in the law do not represent reasonable depletion rates in the case of the designated properties, but are much higher than the true depletion to which the taxpayer is fairly entitled. Moreover, these provisions enable a taxpayer to obtain annual depletion deduction, notwithstanding the fact that he has already recovered the full cost of the property. The deduction is, therefore, a pure subsidy to a special class of taxpayers."

In response, a representative of the Northwest Mining Association criticized the Administration for speaking without adequate experience.

Several years worth of experience later, the position of the Treasury Department was still the same. Secretary of the Treasury Morgenthau denounced percentage depletion as "the most glaring loophole in our present revenue law." (Lerner[4], p. 96)

Similar statements were made by Treasury officials again in hearings on the Revenue Act of 1942. Senators Taft and LaFollette were among those who agreed that "percentage depletion is to a large extent a gift." (Lerner[4], p. 97.) In spite of this opposition, percentage depletion was extended. Ball and sagger clay, rock asphalt, and flourspar were granted a 15% allowance. Ten additional nonmetallics were granted a 15% allowance in 1943, (flake graphite, vermiculite, potash, beryl, feedspar, mica, talc, barite, lepidolite, and spodumene), but with the understanding that the additions were strictly for the purpose of aiding the war effort and that the legislation would expire with the end of the war. The time limitation was apparently rather hotly debated. Senator Barkley, for example, argued that the disputed minerals would have been added in 1932 if they had been considered. (pp. 98-99)[4] Agria notes that producers took full advantage of the opportunity to emphasize the contribution made by their products to the national defense. "Producers lobbied for every mineral which had any possible connection with the war effort." (Agria[8], p. 82.)

The debate renewed at the war's end. Producers of the disputed minerals argued that if the temporary allowance was permitted to expire they would be the only class of taxpayers in the United States forced to pay higher taxes after the war. They also claimed they deserved percentage depletion just as much as the metal producers. Once again, Congress refused to limit the depletion allowance. In fact, the 1947 legislation extended depletion to bauxite, phosphate rock, trona, and several other minerals.

This period has been characterized as dominated by pork barrel politics; Congressmen faced with the realization that percentage depletion was going to be extended anyway decided that some mineral mined in their district might as well have some too. This development is typified by the following exchange during debate of the Revenue Act of 1942:

> Senator Thomas: "I have conferred with the chairman of the committee and other Senators, and I desire to offer an amendment identical in its provisions with the amendment submitted by the Senator from Tennessee, but including one further term, that is 'rock asphalt.'
>
> Senator McKeller: "I have no objection. I am perfectly willing to modify my amendment so as to include the substitute offered by the Senator from Oklahoma."
>
> Senator LaFollette: "...In my opinion this percentage depletion is one of the worst features of the bill, and now it is being extended. We are vesting interests which will come back to plague us. If we are to include all these things, why do we not put in sand and gravel?"

Sand and gravel were added in 1952.

An extensive list of minerals was proposed for percentage depletion in 1949 and 1950 but legislation was temporarily halted by the need to raise revenue for the Korean War. During that time the Truman administration renewed the attack on depletion allowances. President Truman stated in a message to Congress in 1950,

> "I know of no loophole in the tax laws so inequitable as the excessive depletion exemptions now enjoyed by oil and mining interests.
>
> ...I am well aware that these tax priviliges are sometimes defended on the grounds that they encourage the production

> of strategic minerals. It is true that we wish to encourage such production. But the tax bounties distributed under present law bear only a haphazard relationship to our real need for proper incentives to encourage the exploration, development, and conservation of our mineral resources."

More detailed criticism came in testimony by Secretary of the Treasury Snyer, who noted that depletion allowances were costing the Treasury about 500 million dollars, annually, were of little benefit to small prospectors and enabled many high income taxpayers to avoid paying any taxes.[17]

Once again, Congressional response to consideration of depletion was the addition of numerous minerals to the privileged list. The Revenue Act of 1951 raised the allowance for coal to 10%, granted a 5% allowance for sand, gravel, slate, oyster and clam shells, among others, and granted allowances of 10% and 15% to many others.*

By 1954, when the entire tax code was revised, any mineral not yet receiving some depletion allowance probably felt it was the victim of discrimination. That problem was corrected in the 1954 Tax Code, which granted depletion allowances to "all minerals" except those from "inexhaustible sources" such as the air. A distinction was also introduced for minerals extracted from foreign sources in certain cases. For example, lead, mercury, cadmium, and nickel were allowed 23% if mined from U.S. deposits but 15% if from foreign sources.

The next significant change did not occur until the Tax Reform Act of 1969. However, depletion allowances were debated on several occasions in the intervening period. In 1959, the Ways and Means Committee held a panel discussion on mineral taxation. In a brief but informative exchange, Chairman Mills raised the issue of the reasons for depletion allowance:[18]

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*Added at 1951, at 5%: sand, gravel, slate, stone, brick and tile clay shale, oyster shell, clam shell, granite, marble, sodium chloride, bromine; at 10%: asbestos, brucite, dolomite, magnesite, perlite, wollastonite, calcium carbonates, magnesium carbonates; at 15%: aplite, garnet, china clay, borax, fuller's earth, tripoli, refractory and fire clay, quartzite, diatomaceous earth, metallurgical grade limestone, chemical grade limestone.

> Rep. Mills: "As I understand the theory of depletion allowance, we are in this section of the law giving recognition to the fact... that we are dealing with a wasting asset. Is that the basis? ...or has the basis for depletion allowance changed in some way under our present economy to the point that we have also to consider other factors in establishing justification for depletion allowance?"
>
> Mr. Campbell: "I would say that is still one of the main considerations. These provisions are peculiar to the extractive industries. The other consideration is that since the percentage depletion allowance as such is a substitute for the discovery depletion, there is the element of encouraging people to retain that which they found, and to operate it as a business of their own rather than to sell that which they found to someone else."
>
> Mr. Steiner: "Mr. Chairman, I suppose everyone can have their own guesses as to Congressional intent at an earlier time. My own reading of the record shows there were repeated assertions that this program in 1918 was designed not because these were wasting assets but because of the need to stimulate their production."

Other economic justifications for depletion allowances were also discussed:

> Mr. Menge: "I would like to add that the extractive industries are not the only ones which spend large sums that are not immediately realized...there is also not the basic research and development, much of which may result in products of no marketable value whatsoever..."
>
> Mr. Jackson: "We have the same type of research expenditure as the chemical industry does. We are researching all the time for improved beneficiating processes...we have that same type of research, but we also have in addition - and no industry except the mining or extractive industry has it - the expenditures for exploration, of looking for our raw materials, and that is quite different from the non-mining industries."
>
> Mr. Lambert: "I would agree there has been a reallocation of resources [as a result of depletion allowances], but I maintain it has been desirable, and that is what has built our country great with the low energy cost...a chart illustrates very strikingly the ratio of energy consumption to income in various countries of the world...The countries with the lowest energy utilization are the countries with the lowest income."

In 1960, the Democratic Party platform indicated that if elected, John Kennedy might repeat efforts by past Democratic administrations to end depletion allowances. A reference was made to depletion as being "among the more conspicuous loopholes," which the Party vowed to end. However, during the campaign Kennedy spoke about the depletion allowance in favorable terms.[19]

> "The depletion allowances which affect over 100 items should be considered primarily as a matter of resources policy and only secondarily as a tax issue. Its purpose and its value are first of all to provide a rate of exploration, development and production adequate to our national security and the requirements of our economy...The oil depletion allowance has served us well by this test."

Several amendments were introduced in the Senate in 1962 seeking to limit depletion allowances. One would have gradually reduced the allowable percentage for petroleum to 20%. Another, introduced by Senator Douglas, would have introduced a graduated scale for depletion allownaces that varied with the income of the corporation. Senator Douglas argued that this system would protect the "Daniel Boones" of the industry against the large producers. Neither amendment passed. Opponents of depletion frequently cited a recent study by Professor Harberger, who concluded that "More oil can indeed be obtained by tax concessions...(but) if the rest of the economy wants more oil, it should be willing to pay for it by way of a higher market price." While the amendments focused on oil depletion Senator McGee warned that "A Senator who votes for this amendment should keep in mind the extent to which he could be jeopardizing the future of the leading mineral industries of his home state, whether his state produces lead, zinc, copper, iron ore, granite, asbestos, or whatever."

Senator Douglas and other ardent "tax reformists" did not argue directly with predictions about the likely consequences of eliminating depletion allowances. Rather, they focused on depletion because of the magnitude of the tax benefit it provided. Depletion allowances were "the citadel of privilege", and therefore the fight for its reduction was symbolic of the entire fight for tax reform. Senator Douglas, for example, stated on the

Senate floor:

> "Mr. President, it is solemn truth that the depletion allowance should be greatly reduced. We are going to be beaten tonight; but in God's good time we will not be beaten, and the powerful oil interests which have their representatives on this floor, ...and who will be victorious this time, in due course will not be victorious, because they are defending something which is morally and economically wrong."

Depletion allowances were again subjected to extended discussion prior to the Tax Reform Act of 1969. While perhaps less eloquent than Senator Douglas, critics of depletion were better prepared to argue the merits with their opposition. The improved political climate for tax reform may also have lessened the need for dramatizing the issue. For example, Representative Meeds stated before the Committee on Ways and Means,

> "The risks referred to (in mining) are limited to exploration, for the expenses involved in the development of the site are quite predictable. But even exploration can be predicted. We can see from statistics that giant corporations dominate the field. It is an economic fact that risks become more regularized and predictable as the area and time span of operation increases...
>
> The oil and mining industries often argue that their capital is used up, never to be replaced, ...More accurate analysis would say that the oil and ore is really being removed from inventory and being placed in a saleable form...If we think of oil and ore in the same light as land, their production is not a piecemeal realization of a capital expenditure, but like real estate, a barrel-by-barrel production of ordinary income, for the sellers are in the business of digging up and selling oil and ore... The percentage depletion allowance lessens our defense capability because our mineral and oil resources must be exploited before the deduction is allowed...A fourth argument by the proponents is that percentage depletion is an aid to the financing of discovery. But is this so? The deduction is not given when the mineral is discovered, but only when it is dug or pumped from the ground."

Meeds also accused percentage depletion of misallocating resources, aggravating inflation, damaging the integrity of the tax code, and costing the taxpayers over a billion dollars.[20]

One interesting suggestion raised during the hearings was the possibility of reverting to discovery depletion. Mr. Wilson, a former petroleum engineer testifying at the hearings, responded that valuation within a 6 month period "is virtually impossible within the limits of accuracy needed for this type of determination." While this suggests that the accuracy of the percentages established by reference to experience under discovery depletion is open to question, petroleum officials also insisted that discovery allowances would actually be higher than existing rates. (Mr. McClure, President of the Petroleum Association of America, estimated that discovery values now would be 34% or 35% of gross income based on "rather extensive review." p. 3185[20].)

Whether due to improved criticism or the change in political climate, the Tax Reform Act of 1969 reduced the percentage depletion allowances for several categories, the first such reduction in the history of depletion provisions. The rate of depletion for oil and gas was lowered from 27½% to 22%, and minerals which had received 23% were also granted 22%. Minerals at 15% were reduced to 14%, except for domestic gold, silver, copper, iron ore and oil shale, which were felt to be in critically short supply. However, special favoritism was not entirely absent; molybdenum, which had received a 15% allowance, was increased to the 22% category.

THE INFORMATION GAP

The assumption is sometimes made that because Congress has continued depletion allowances for so long there must be good reason for it. For example, Representative Boggs stated during the panel discussions in 1959,[21] [22] [23]

> "Do any of you attribute any significance to the fact that each time Congress has studied this problem, we have reaffirmed the necessity for this concept of the law, and have actually extended it? Would this not indicate that despite the heat with which it has been attacked from all sorts of sources, there must be a tremendous amount of merit to this concept of the law?"

While it is unlikely that this argument is made very seriously, it does seem important to emphasize the lack of information on the costs and benefits of continuing depletion allowances. Reference has already been made to the analytical weaknesses of setting rates for percentage depletion based on discovery values that were themselves felt to be excessive. (Lerner[4], p. 35; Agria[8], p. 81.) This fact alone casts serious doubt on the justifiability of percentage depletion rates.

However, the problem goes deeper than the use of arbitrary values from the discovery depletion era. For most minerals on the depletion list (all those added after 1932), no studies were even attempted to determine appropriate depletion allowances. The studies that were undertaken are also of questionable value by today's standards. Lerner[4], writing in 1952, questioned the reliability of those early examinations of depletion (p. 36).

> "The mere fact that a certain level of allowance has prevailed for a long time does not in itself mean that such a level is correct. In recent years there has been frequent reference to various studies of depletion made in the late 20's and early 30's which alleged equivalence between percentage and cost depletion. The plain fact of the matter is that those studies were by no means reliable, and the passage of time cannot confer validity upon findings which were incomplete or inaccurate. Recent studies in the measurement of excess depletion allowances, such as those by the Treasury, including those submitted to the President's Materials Policy Commission, suffer from certain obvious technical difficulties.."

Another information gap exists as to the relative costs and benefits derived from depletion allowances. This problem was raised during the 1959 panel discussions: (Appendix B, p. 512, 535.)[18]

> Mr. Galvin: "...some rather detailed objective study must be made of economic data to show what the public benefit is from depletion, and to show that benefit in relation to costs so that we could know once and for all whether the method that we are using here really causes the reallocation that we want to cause."

> Mr. Steiner: "...It seems to me that, following up with what Mr. Galvin said earlier, here is the crucial question on which we need facts: Just how much difference does this make? And... how important is this to our national defense? I think this is a question we on the panel cannot answer. If we are buying reserves we do not need, the benefits will be low. If we are buying reserves that are critical to our survival, the benefit is very, very large."

Some studies have been done in this area since then, particularly with respect to the petroleum industry,[24] but the information available on most minerals is still totally inadequate. The existing state of affairs was well summarized by Willis Snell, a participant in a Ways and Means Committee panel discussion in 1973:[25]

> "It must be emphasized that, at least for hard minerals, we have little statistical or other data on the basis of which to judge the actual effect of percentage depletion... So far as I am aware, there is no published information as to its actual economic impact on any branch of the hard mineral industry....We do not have accurate or current information as to how much percentage depletion has been allowed to producers of any given mineral, let alone how that allowance compares with the discovery or capital value of the mineral, or the effect of the 50% of taxable income limitation, either in terms of the number of miners affected or the dollars of tax deductions lost because of it."

The question of the probable effects on prices of eliminating depletion allowances is a particularly important one. Yet even the American Mining Congress was unable to offer an estimate of the likely price effects of eliminating depletion allowances on one mineral, iron ore: (p. 2205.[25].)

> "Loss of the depletion allowance would result in substantial increases in the prices of iron ore and the products made from iron ore. Unfortunately, we are not in a position to quantify this answer. To do so would require assumptions (1) as to the elasticity of demand at a given point in time and a given point on the demand curve, (2) as to the pyramiding effect of increases in iron ore prices at subsequent levels, (3) as to the long-run effect on the direction of investment funds into the industry, and (4) as to the treatment of depletion allowances on other mineral products that are actual or potential substitutes for iron products."

The lack of certainty as to effects on prices and profits is one argument industry representatives give in opposition to allowing higher prices as opposed to lower taxes as a way of inducing investment in minerals. One petroleum official argued before the Ways and Means Committee that "price does not operate fast enough" and the prospect of lower profits for at least the short run would seriously damage investment prospects in the industry. (Richard Gonzalez[25], pp. 1462-64.)

The ultimate impact of this information gap on policy making is itself a political judgment. Industry spokesmen argue that any provision of the tax code as deeply entrenched as depletion allowances should be continued until critics prove that changes will not be harmful.[26] On the other hand, opponents of depletion argue that industry is in the best position to supply the necessary data[27] and that there is sufficient understanding of the depletion allowance to know it serves no useful purpose. (Mr. Gray[18], p. 505.)

DEFINITION PROBLEMS

The substitution of percentage for discovery depletion ended the judgmental problems involved in evaluating the worth of mining discoveries. However, a host of difficult administrative problems remained, and many new ones were created as additional minerals were added to those already allowed depletion. For purposes of providing an overview of these administrative problems, four problem areas will be discussed. However, the reader is warned that an in-depth consideration of these issues is outside the scope of this paper; the technical questions surrounding the operation of the depletion provisions are the source of employment for many tax lawyers.

(1) "Minerals"

Section 613 lists various minerals and the allowable rates of depletion. However, neither the Code nor, with a few exceptions, the Internal Revenue regulations provide chemical definitions of the various "minerals". A somewhat bizarre example of the possible issues raised by this section is the case of a taxpayer who attempted to take depletion on the skills of his employees. A court ruled that such skills were not within the meaning of "other natural deposits" entitled to a deduction (Heisler v. U.S., 463 F.2d 375; 9th Cir. 1972.).

An example of a more frequently encountered problem is the definition of quartzite, a term used to describe certain varieties of stone, but not always with the same meaning. The distinction is important since quartzite is allowed depletion at a rate of 14% whereas most other forms of stone are allowed only 5%. Similarly, a rather ephemeral boundary distinguishes limestone, depletable at 15%, from calcium carbonate, which is entitled to only 10%.

Another problem with potential relevance to recycling arises from the extraction of minerals from tailings or waste piles. In general, depletion of waste materials (other than cost depletion for the purchaser of such materials) is allowed only in narrowly circumscribed instances. Until 1960, the position of the I.R.S. was that a waste pile would only be considered a "mine" for purposes of depletion allowances if processing the waste was an integrated step in the mining operation.[28] However, the 1954 Code included an amendment specifically allowing income from the extraction of minerals from prior mining activities to be included within gross income for depletion. The waste materials can be from treatment processes or the original extraction, but in either case the reworking must be done by the owner of the natural deposit.

Since minerals derived from waste piles contribute to total resources just as much as those extracted from natural deposits, the existing restrictions seem unfairly discriminatory. This approach may have been justified when depletion was based on discovery, but even under that system tax benefits could only be derived from the sale of minerals. One tax court decision opened a small crack in the I.R.S. regulation by allowing depletion of a dump being reworked for minerals different than those originally mined. In such circumstances, the court found, the dump had not lost its character as a "natural deposit". (Pacific Cement & Aggregates, Inc., 31 T.C. 136). However, the I.R.S. has not acquiesced in the court's decision.

(2) Economic Interest

Under a decision of the Supreme Court and I.R.S. regulations (1.611-1b) depletion deductions are allowed only to the owner of an "economic interest" in a mineral deposit. The problem arises when the original owner of a mine contracts with another for its development. Unless the owner transfers his interest, both parties will have income "from the property" and therefore will arguably be entitled to a depletion allowance.

After a 1918 Supreme Court decision dealing with the 1909 Act denied a deduction for depreciation to a lessee, the 1918 Act and every revision thereafter included the statement that "In the case of leases the deductions allowed by this paragraph shall be equitably apportioned between the lessor and lessee." The Supreme Court later allowed depletion deductions to be taken by lessees under earlier Acts as well, so long as the mineral interest was "acquired by investment" and the taxpayer's return on investment depends solely on production.

At various times the I.R.S. has attempted to restrict the availability of depletion allowances to certain arrangements. For example, regulations at one time denied a deduction for income earned as a share of net profits from a mine. This position was rejected by the Supreme Court (Kirby Petroleum Co. v. Commr.,326 U.S. 599; 1946), and the prevailing view appears to be that the determination of an "economic interest" depends upon the totality of facts in each case. The Supreme Court has specified seven factors to be considered, although without indicating their relative importance; (1) the existence of an investment in the mineral deposit that will be depleted by its extraction; (2) the lack of capital investments recoverable through depreciation; (3) the contract must not be terminable at the will of the owner; (4) the transfer of a capital interest in the mineral deposit; (5) the transfer of ownership of the mineral as it is mined; (6) the right to a share of the proceeds resulting from the sale of the mineral rather than a fixed fee; and (7), the right to seek compensation other than from the landowner (Parsons v. Smith, 359 U.S. 215; 1959).

While the problem of defining an "economic interest" is usually not a major concern, at least in terms of overall mining operations, it is important for two reasons. First, it indicates the kind of administrative problems that continue to plague the depletion provisions. Second, the extension of depletion to persons who have not done any exploraton or development undercuts one of the most frequently cited reasons for granting the depletion deduction.

(3) "Gross Income from the Property"

Section 613 limits depletion allowances to a percentage of income from the mining property. (For more exhaustive treatment of these issues, see P. Schmid and D. Williams[29].) Section 614 allows the aggregation of mineral properties under certain circumstances, a procedure which may allow the taxpayer to circumvent the 50% of taxable income limitation in determining allowable deductions. Prior to 1954, when section 614 was adopted, each separate interest was taxed as a unit. Now, a taxpayer with operating mineral interests in the same "operating unit" can aggregate them for tax purposes, and under certain circumstances a single interest may be treated as more than one property. Under I.R.S. regulations, an "operating unit" refers to a producing unit and not to an administrative or sale organization. Factors considered to be evidence of an operating unit are common personnel, supply facilities, processing or treatment plants, and storage facilities.[30] This provision would appear to favor the large companies, who have greater operating flexibility and are therefore more likely to meet the I.R.S.

requirements. (The use of the aggregation provisions is explained in detail, including examples of its effect on deductions in Tax Management, Worksheets, 1-3.).

Having selected a taxable unit, the next problem becomes calculating the gross income from mining. The definition of mining is a controversial subject and has spawned considerable litigation since it is in the taxpayers' interest to include as many processes as possible before calculating allowable depletion. Early Revenue Acts did not define the scope of allowable mining processes.[31] The earliest Treasury regulations, issued under the 1913 Act, defined gross income in terms of the market value of the mineral. Regulations issued under the 1921 Act refined the definition to the price of the raw material, before refining. The adoption of percentage depletion made further precision necessary and regulations issued under the 1932 Act listed specified processes which could be applied prior to computing gross income.

During World War II, when Congress added numerous minerals to the list of those entitled to depletion, an effort was made to at least partially resolve the problem of defining a cut-off between mining and manufacturing. The Revenue Act of 1943 defined mining to include:

> "not merely the extraction of the ores or minerals from the ground but also the ordinary treatment processes normally applied by mine owners or operators in order to obtain the commercially marketable mineral product or products."

Certain specifically eligible processes were also listed. An allowance for transportation costs up to 50 miles, or further if the Treasury ruled that moving longer distances was necessary, was added in 1950 to cover the costs of hauling minerals from the point of extraction to plants for "ordinary treatment processes".

The implementation of these provisions has probably been the greatest source of uncertainty, and undoubtedly the greatest source of litigation under the depletion sections of the tax code. The incentives for attempting to extend the cut-off point are very great; in some cases, including the additional income derived from a particular treatment process may be more important than the allowable rate of depletion. The I.R.S. attempted to devise various rules of thumb for distinguishing "mining" from other manufacturing processes. Judicial responses varied.

One test, which initially achieved some success, disallowed any process which affected a chemical change. This rule was rejected because a taxpayer was able to demonstrate that chemical processes were necessary to produce the first "commercially marketable" product from the mineral in question, calcium carbonate (Dragon Cement Co. v. U.S., 244 F. 2d 513; 1st Cir. 1957).

Until 1960, the I.R.S. had little success in the courts in restricting the scope of "ordinary treatment processes" in other than obvious cases. (The courts have been fairly strict in disallowing income received from sources other than the sale of minerals, for example from the sale of discarded equipment or business interruption insurance.) The prevalent judicial attitude was reflected in a "profitability" test, which viewed any process necessary to produce a commercially marketable product as a "mining" process for purposes of depletion (e.g., Iowa Limestone v. Comm., 269 F. 2d 398; 8th Cir. 1959).

In 1959, hearings were held on possible legislative revision of the definition of mining. The Treasury Department submitted a proposal to eliminate the commercial marketability test, indicate specific processes entitled to depletion, and specify a cut-off point beyond which further processes would not be considered mining. (Agria[8], p. 87.)

Legislative action was delayed pending the outcome of a Supreme Court case reviewing an appellate court decision that adopted the "profitability" test. In Cannelton Sewer Pipe Co. v. U.S., 364 U.S. 76 (1960), the Court rejected the theories developed by the lower courts. The primary inquiry was at what point the ordinary miner (as opposed to the integrated miner-manufacturer) shipped his product. If all the producers in the relevant market were integrated, an estimation of the proportion of income from the first marketable product was necessary even if the first marketable product could not be sold profitably. Later court interpretations went even further, finding that the lack of a market for the mineral in its raw state did not extend the scope of allowable mining processes.[32]

The Congressional response was to adopt the basic ideas suggested by the Treasury Department. The old definition of mining was deleted and specific cut-offs for some minerals were added. Additional flexibility was added by giving the Treasury the authority to add other processes. The general theory behind the choice of specific processes was that "mining" should include processes necessary to prepare the mineral for sale prior to refining. Thus, the separation of waste material from the raw mineral is subject to depletion, but the introduction of any chemical changes is not. While not as drastic as the approach taken by the Supreme Court's Cannelton decision, the amendment did reverse the trend toward increasingly liberal interpretations of mining processes.

One issue left open by the 1960 legislation is whether the use of a nonmining process establishes a cut-off point beyond which otherwise acceptable processes must be considered nonmining. The I.R.S. regulations adopted this "sudden death" approach with an exception for the use of nonmining processes "necessary of incidental to" a mining process, or where application of the rule would discriminate between similarly situated producers.[33] The need for continued case by case analysis seems apparent. However, one optimistic commentator has suggested that "the major controversies have been resolved" by recent I.R.S. regulations.[34]

Numerous other questions have also arisen in the determination of gross income limitations. The infinite variety of transportation arrangements, for example, require considerable administrative review despite the general rule allowing profits for haulage to a treatment plant within 50 miles of the point of extraction.[35] Similar administrative problems also arise in deciding whether profits from bagging and packaging are allowable.

The payment of royalties also creates problems for the I.R.S. The courts have firmly upheld the right of the I.R.S. to exclude from gross income any fees paid as a fixed amount per unit of production or as a percentage share of net profits (e.g., Burton-Sutton Oil Co. v. Commr., 328 U.S. 25; 1964). The problem can be much more subtle, however. For example, the I.R.S. has also excluded the payment of taxes by a lessee on behalf of a lessor from gross income on the premise that such payments constitute a substitute for higher rent.

Another major source of difficulty is the allocation of income between mining and nonmining activities. Vertically integrated manufacturers must compute a representative market price for the minerals used in their production processes before apportioning income between mining and nonmining activities. When a representative field price is not available, regulations generally require the application of a proportionate profits method to determine the percentage of income generated by each stage of the production process.

Recent Congressional action indicates that the question of the cut-off point between "mining" and "manufacturing" is still very much a political issue. An amendment passed October 16 allows producers of the ore trona to include income from the calcining process, a change which will increase the producers' depletion deductions by $2 million annually.[36]

(4) "Taxable Income from the Property"

After all other calculations have been made, the total depletion deduction must fall within the 50% of taxable income limitation. Since excess depletion is of no use to the taxpayer, (it is in his interest to allocate as much of possible expenses to non-producing properties or other nonmining activities). Problems frequently arise in attempting to apportion administrative and overhead costs, and the large, integrated producer has a significant advantage in being able to maneuver these expenses. I.R.S. regulations define taxable income from the property as the "gross income from the property" less allowable deductions attributable to the property, including overhead and operating expenses, costs of "mining" processes, and amounts deducted for exploration and development (1.613-5).

Taxable income from the property is limited by the amount determined to be gross income from the property, but there are many expenses which arguably bear this relationship. Over the years, courts have decided that the following expenses must be deducted from gross income in proportion to the relationship of mining costs to other activities: state and local taxes, interest paid on money borrowed to purchase the mineral property, amounts paid in settlement of silicosis claims, and losses resulting from the abandonment of mining equipment.[37] Courts have reached different conclusions on the appropriate treatment of the costs of packaging and advertising.[38]

When the taxpayer owns more than one property, expenses must be allocated to each, with a significant tax benefit being derived from the allocation of costs to the nonproducing properties which are not yet receiving a depletion allowance. The I.R.S. is in a difficult position to challenge many allocation decisons since the taxpayer's intent may be an element in the determination.

> "Take, for example, the case, of a miner who incurred exploratory expenditures because he needed to have greater mineral reserves in order to continue his operations. If his efforts were confined to determining the extent and quality of the mineral deposit which he was presently extracting, all the cost thereof would be directly attributable to that property if the survey applied only to that deposit within the area limits of his lease or land.

> If, however, the survey was for the purpose of finding distinctly separate deposits either on his lease or land or on other areas, such costs need not be used in determining taxable income from the operating property. If property were acquired as a result of such exploration and when developed it was aggregated with the presently producing property, §614 (c)(A) requires that the exploration costs would have to be deducted in recomputing the taxable income for the year of exploration for the purpose of limiting percentage depletion on the aggregated property. It is readily apparent that the question as to the taxpayer's intent in making the exploration will need a reasonable approach." 39

Whether because of this problem of intent or other reasons, many mining firms have been extremely successful in shifting exploration and development expenditures away from the depletion account. A relative measure of success has been calculated by Page[5], who estimates that for the metals allowed 15% depletion, 98% of capital is recovered other than through the depletion account.

FOREIGN TAX CREDIT

Sections 901-905 of the Internal Revenue Code (Title 26, U.S.C.A.) set forth the basic provisions of the foreign tax credit. Within certain limitations, the foreign tax credit allows a personal or corporate taxpayer to offset his domestic tax liability on income earned in foreign countries by the amount of taxes paid to foreign governments. The usual rationale offered in defense of the credit is that:

> "If both countries with a claim for taxing a particular transaction were to impose their tax without regard for the other, the result would be double taxation with burdens that would deter international business. Indeed, it would be possible, in the absence of accommodation mechanisms, for tax burdens to exceed 100 percent of the income earned. The foreign tax credit is the basic mechanism by which the United States accommodates its tax system to that of foreign jurisdictions. If there were no foreign tax credit, American companies in many instances would have no practical alternative to divesting themselves of their foreign operations." Stanford G. Ross, in General Tax Reform, Panel Discussions before the Comm. on Ways & Means, House of Representatives, 93rd Congress, 1st Sess. (Part 11) (1973), p. 1725.

HISTORY

The original Internal Revenue Act of 1913 allowed foreign income taxes to be deducted but not credited. Foreign taxes were treated like any other business expense. The Treasury Department also adopted a policy of deferring the imposition of taxes on income earned by foreign subsidiaries until repatriated as dividends, a decision almost as significant as granting the tax credit.[39]

The increase in foreign tax rates that accompanied World War I resulted in pressure on Congress to eliminate the harshness of "double taxation". Congress responded favorably and included a foreign tax credit in the Internal Revenue Act of 1918. The credit was to be limited to "income and profits taxes" as opposed to royalties or other business expenses, a distinction that has been the source of much litigation. A major question was resolved when the courts determined soon after the Act's passage that the credit was to be allowed for applicable foreign taxes, even if contested or not yet paid.[40]

The Revenue Act of 1921 sought to prevent corporations from using their foreign tax credits to offset domestic tax liability. An overall limit was added to prevent this abuse. Further restrictions were added in 1932; a per country limitation was added and taxpayers were (only allowed to credit the lesser of the overall limitation or the per country). In addition, a provision was added disallowing any deduction for the excess of foreign taxes over permissable credits.

The credit was subjected to a major attack in 1934 when a subcommittee of the House Committee on Ways and Means recommended that foreign income taxes be allowed only as a deduction. The subcommittee report concluded that "The present provision discriminates in favor of American citizens and domestic corporations doing business abroad as compared with those doing business in this country." The unfairness of not allowing a similar credit for state and local taxes was specifically noted. Despite agency interests which usually seek to increase tax revenue, the Treasury Department representatives testified in opposition to the measure:

> "In the judgment of the Department the present arrangement seems fair and should be continued. If it is not continued, American taxpayers doing business abroad will have an additional incentive to organize foreign corporations to take over their foreign business, with resultant loss of both business and revenue therefrom. It is quite clear that the elimination of the foreign tax credit will not increase the revenues to the extent of the taxes which American taxpayers now save by virtue of it. The amount in any case, however, is relatively small....For 1933 the total of foreign tax credits is estimated at not to exceed $8,000,000." Revenue Revision, Hearings before the House Comm. on Ways & Means, p. 78 (1934).

Treasury recognized the inequity involved in the dissimilar treatment accorded state taxes. However, the Department report argued that "The fact that this duplication already exists in this country is not a satisfactory reason for increasing the duplication in other directions."

The subcommittee proposal was also vigorously challenged by industry representatives. An official from the American Mining Congress noted that elimination of the credit would necessarily hinder foreign trade, and warned: "It of course follows that any serious decline in foreign trade would have an unfavorable reaction on our employment situation and the general prosperity of the country."[41] As evidence, the mining official cited a Commerce Department report which calculated that U.S. exports were responsible for employment for 2,400,000 families, with probably a like number employed in related industries.

The final House report compromised by seeking to cut the credit in half. The entire idea was rejected in the Senate and dropped from the final bill.

Several provisions in the Revenue Act of 1942 broadened the scope of the credit. First, the definition of "income tax" was expanded to include certain taxes in lieu of income taxes. Second, corporations were granted the right to credit the taxes paid by a foreign subsidiary (subject to the per country and overall limitations). Third, a requirement that the taxpayer elect in advance whether to credit or deduct foreign taxes was eliminated. The motivation for these liberalizing amendments was apparently the "extremely high rates of taxation" imposed by several governments during World War II, which caused considerable hardship for some American corporations.[42]

The appropriate method of computing a limit on tax credits was reconsidered in 1954. On the recommendation of the Treasury Department, the overall limitation was repealed and the per country limitation required. This provision was amended again in 1960 when taxpayers were given the option of either the overall or per country limitation. While this eventful history may be no more than the result of changing political fortunes (allowing an option is the most advantageous provision for the taxpayer), the two alternatives do serve different policy concerns:[43]

> "The overall limitation reflects a view that all foreign income should be lumped together and all foreign taxes allowed to apply against United States taxes on all foreign income. The notion behind this limitation is that the individual foreign countries where income is earned and their taxing systems are not particularly important from a United States taxing standpoint....The per-country limitation reflects a view that our rules should treat separately each particular foreign jurisdiction where income is earned or a loss is incurred....This may be seen as a more neutral tax principle since a taxpayer contemplating a foreign investment must estimate the combined United States and foreign tax results solely in terms of the interaction of the taxing systems of two countries." Stanford G. Ross, p. 1726.

The Technical Amendments Act of 1958 added a 2-year carry-back and 5-year carry-forward for credits in excess of permissable amounts in any given tax year.

In 1961 the Kennedy administration advocated elimination, or at least restriction of deferral privileges as a way of regulating the growing number of tax havens in countries with low tax rates.[44] The problem was that a U.S. company could form a holding company in a country with low tax rates to receive income from operations in other countries and through foreign reinvestment avoid U.S. taxation indefinitely. Devising workable legislation, however, proved to be extremely difficult because of the definitional problems involved in distinguishing "tax havens" from "legitimate" foreign enterprises.

The legislation that finally emerged, subpart F, was the result of some

Congressional compromise. The House bill would have gone far toward elimination of deferral, while the Senate would have made no change. The compromise worked out in conference, subpart F, is one of the most complicated provisions in the entire tax code. The basic scheme works as follows:

> "Essentially, these provisions impose U.S. tax currently on the undistributed foreign base company earnings of a foreign corporation controlled by U.S. stockholders. They also tax to the U.S. shareholders any earnings of a controlled foreign corporation reinvested in United States property. There are several exceptions to imposition of the subpart F tax. One of these is the so-called '70-30' rule, under which, if foreign base company income is less than 30% of gross income, none of the income is currently taxable...Under the "minimum distribution" exemption, ...subpart F tax may be avoided if the foreign company makes current distribution to its U.S. stockholders, the tax on which, when combined with the effective foreign rate on undistributed earnings, equals 90% of the U.S. 48% rate on the combined earnings." Thomas Jenks, in General Tax Reform, p. 1741

In 1966, an amendment was passed allowing an alien resident the right to use the foreign tax credit. Previously, an alien resident was only allowed to use the credit if his home country granted a similar right to U.S. citizens. However, the President was given the authority to reinstitute the restriction by designating specific countries, and the old provision still applies to income earned by foreign corporations and non-resident aliens.

The most recent amendment to the foreign tax credit came as part of the Tax Reform Act of 1969. Prior to 1969, multiple tax benefits were possible on foreign mineral income; a corporation could receive a depletion allowance based on a percentage of gross income which included foreign income taxes.[45] This possibility was limited, although not totally eliminated, in the Tax Reform Act. Under section 901(e), foreign taxes on mineral income at higher than U.S. rates are not allowed as credits to the extent attributable to percentage depletion. (That is, they cannot be averaged out with lower taxes on non-mineral foreign income under the per-country limitation or with income from other countries under the overall limitation). However, a double benefit is still possible when the credit does not exceed the amount determined by U.S. tax rates.

RELATED PROVISIONS

Several other provisions of the tax code are also of potential benefit to U.S. firms undertaking mining activities in foreign countries.[46] Special tax treatment is accorded businesses which organize as Western Hemisphere Trade Corporations, Less Developed Country Corporations, or U.S. Possession corporations, provisions directed toward encouraging business development in specific parts of the world Similar tax benefits are also available to corporations incorporated under the China Trade Act of 1922. In order to grant exporters some of the same tax incentives given foreign investors legislation was passed in 1971 creating Domestic International Sales Corporations.

CURRENT DEBATE

A panel of experts discussed "Taxation of Foreign Income" before the House Committee on Ways and Means during 1973. Many issues were raised, but the two questions most hotly debated were the need for further restriction on deferral and the value to the economy of continuing the foreign tax credit. The intensity of the debate may reflect the magnitude of the stakes; deferral represents a savings of up to $1 billion, and before-tax profits on U.S. foreign investment were about $18 billion in 1970, 20% of the total profits of U.S. corporations.

EXPENSING OF EXPLORATION AND DEVELOPMENT COSTS

The mineral industry receives significant tax benefits from the expensing of mining exploration and development costs. Sections 616 and 617 of the Internal Revenue Code allow the taxpayer the option of "expensing" costs of mining exploration and development, that is, deducting them in the year incurred rather than through capitalization and gradual depreciation. This deduction is only granted for expenditures that would not otherwise be entitled to a deduction, and is also not allowed for purchases of depreciable property (or the costs of acquiring such property).

The primary advantage of these provisions is one of timing:

> "The privilege of expensing allows a hard mineral firm to take deductions earlier than would be the case under the concept of depreciation, which would match the deductions against the flow of income. Taking deductions sooner has the effect of pushing tax payments off into the future. This is equivalent to an interest free loan from the Treasury for the amount of the tax deferred and for the same length of time that the deduction would have been taken in the absence of the expensing privilege....And with inflation, an interest free loan is made more attractive by the amount of the rate of inflation."

A. DEDUCTION IN OPERATION

Capitalization and depreciation are the usual methods prescribed by the tax code for deducting costs of tangible property with a limited useful life (§167, 1002, and 1016). These provisions still apply to mining costs, including exploration and development. However, a large proportion of exploration and development expenses are for non-depreciable items such as labor, testing of samples, and construction of access tunnels. The percentage of exploration and development costs which benefit from this provision does not appear to be available, although one can imagine only rare circumstances in which the taxpayer would not want to use it. Page estimates that as a general principle, the mineral industries have been very successful in avoiding capitalization of the costs of mining.

(See Page, pp. 12-16) One source estimates that intangible non-depreciable expenses amount to around 75% of the cost of drilling and development for oil and gas. (Hambrick, in General Tax Reform Panel discussions, p. 1370.) The usual tax theory for treatment of this type of business 'start-up' cost is that such costs should be deducted over time to match the flow of income generated by the mine. (This option is still available to the taxpayer.) Until 1951, this was the accepted method for deducting these expenses.

Expensing is much more generous. Section 617 allows the taxpayer an unlimited deduction for the mineral exploration costs discussed above (other than for oil and gas wells) if spent in the U.S. Deductions for exploration outside the U.S. are limited to $400,000, taking into account any deductions for deposits in the U.S. (including deductions in prior years). The deductions are, however, subject to "recapture", i.e., the amount of income shielded by the deduction is eventually subject to taxation when the mine reaches the producing stage. (A mine is considered to have reached the producing stage when "the major portion of the mineral production is obtained from workings other than those opened for the purpose of development, or when the principal activity of the mine is the production of developed ores or minerals, rather than the development of additional ores or minerals for mining." House Rep. No. 1237, 89th Congress, 2d Session, p. 9.) This comes about in one of two ways at the election of the taxpayer: (1) the exploration deductions are added to the income from the mine, or (2) depletion deductions from the property in the amount previously expensed are foregone. (The amount added to income or subtracted from depletion deductions is adjusted to reflect any reductions in prior depletion allowances caused by the §616 and 617 deductions. See Reg. §1.617-3). Under the first alternative, the amount recaptured is added to the basis in the property so that the taxpayer is in the same position he would have been had the costs been capitalized originally. If the property is sold or otherwise disposed of before exploration expenses have been completely recaptured, the taxpayer will recognize additional gain. (See Merten's,[1] Ch. 24, pp. 53-54, and Reg. 1.617-4.)

The deduction for mining development is provided in §616. The "development" stage includes expenditures made "after the existence of ores or minerals in commercially marketable quantities has been disclosed" (and therefore extends to some production costs as well; See Reg. §1.6161 (a).) The deduction, like that for exploration costs, is limited to expenditures for non-depreciable property which are not otherwise deductable, and the taxpayer may elect to capitalize the expenses and deduct them rateably as units of produced minerals are sold. (During the development stage, the deferment option only applies to the excess of expenditures over net receipts from the deposit. Unlimited deferment is permitted during production. See Reg. §1.616-2.).

Sections 616 and 617 apply to all minerals entitled to percentage depletion except for oil and gas. Oil and gas taxpayers are less favorably treated. Under §263(c), a deduction may be taken for intangible drilling and development costs of oil and gas wells. The deduction is not available for exploration costs, except where drilling is involved. Section 263 also does not provide the option of deferring the deduction and taking it as a prepaid expense when production begins, a valuable option when expenses exceed the taxpayers income from other sources. The mining taxpayer is also allowed to choose between expensing and deferring the deduction on an annual basis, whereas the oil and gas taxpayer must make one binding election between expensing and capitalizing.

B. DUPLICATION OF BENEFITS THROUGH DEPLETION

Reference has already been made in the Depletion section to the possibility of a "double deduction" for certain expenses because of the overlap of depletion and expensing allowances. This comes about because depletion, unlike the depreciation method allowed other industries, is not based on actual cost. In industries restricted to depreciation, allowing an expenditure to be expensed means an equivalent reduction in allowable depreciation. The mineral industries, because percentage depletion continues even when deductions are in excess of actual expenditures, do not lose anything by expensing. In effect, every dollar expensed represents a net gain to the industry, subject only to the possible limits imposed as a result of the 50% of net income restriction on depletion allowances. (Exploration expenditures are only deducted from net income for purposes of the 50% of net income limitation on depletion allowances when such expenditures are "from the property" being depleted. This sometimes gives the taxpayer added room to attempt to increase his allowable deductions.)

The same incentives exist for mineral industries to seek separate depreciation deductions for capital investments related to the mine. For example, if the cost of a drilling machine is added to the capitalized value of a mine, the taxpayer gains nothing since the additional cost does not increase allowable depletion allowances. But if the taxpayer is allowed depreciation deductions on the machine, his total deductions will increase. Courts have been fairly generous in this regard, allowing depreciation of any asset which has a measurable life of its own apart from the mineral deposit. (See, e.g., Amherst Coal v. U.S., 295 F. Supp. 421; D.C.W.Va. 1969;)

C. LEGISLATIVE HISTORY

The mining industries were not given the option of expensing exploration and development expenditures until 1951. Prior to that time, such expenditures had to be capitalized. However, the oil and gas industries were allowed to expense intangible drilling and development costs much earlier.

The option of expensing for oil and gas taxpayers originated with a Treasury Decision in 1917. T.D. 2447 granted taxpayers the option of deducting, "as an operating expense," "the incidental expenses of drilling wells, that is, such expenses as are paid for wages, fuel, repairs, etc...." The reason for granting this option is somewhat obscure. One authority suggests,

> "There was apparently a feeling among accountants at that time that while the tangible costs clearly had to be capitalized and depreciated, the intangible costs had to be expensed...A number of requests were made to the Bureau of Internal Revenue for permission to capitalize intangibles. The officials were an obliging lot, and they decided to permit that 'option'." J. Hambrick, in General Tax Reform Panel Discussions, p. 1371 (1973).

T.D. 2447 was continued in future Treasury regulations. At first, the option was only available to owner-operators, but it was soon extended to lessees as well. The Treasury Department attempted to eliminate the privilege in 1942. However, because the provision had been in force for so long, the Department felt that any change would require legislation (a position suppported by some court decisions). Congress took no action on the proposal.[47]

The first real threat to the expensing option occurred in the courts. Although the privilege was not directly at issue, a federal Court of Appeals indicated that the regulation was void as inconsistent with other tax laws. (F.H.E. Oil Co. v. Commissioner, 147 F.2d 1002; 5th Cir. 1945). The I.R.S. announced it would disregard the court's opinion, and in an extraordinary action, Congress passed a concurrent resolution declaring support for continuation of the option. (House Concurrent Resolution No. 50, 79th Congress; for further discussion of the background of the resolution, see Lerner[4], pp. 22-24.).

The Treasury again sought to restrict the value of the expensing provision in 1950. The Department proposed that for purposes of computing depletion "gross income" be reduced by the amount of intangible expenditures expensed. Congress rejected the idea.[48] The regulation was finally enacted into law by Congress in 1954 as §263(c).

While mining did not receive the same privilege for expensing intangible costs provided in T.D. 2447, the industry did receive some early tax benefits. A regulation first issued in 1921 allowed an immediate deduction for development costs up to the amount of net receipts from minerals. Additional amounts of income were capitalized. (See *Korth v. Mountain City Copper*, 174 F.2d 295; 10th Cir. 1949).

In 1951, Congress adopted the forerunners of sections 616 and 617. Development expenditures were given the same status they have under the present tax code. Exploration costs, however, were treated somewhat differently. The taxpayer was allowed to expense up to $75,000 a year in any 4 years, or a maximum of $300,000. This amount was not subject to recapture.

The Senate Finance Committee gave the following explanation for allowing the expensing of exploration expenditures:

> "It is generally recognized that the present available mineral resources of this country are in many respects deficient in view of the ever-increasing demands of our economy, especially in an emergency period such as the present...Intensified and expanded efforts to find new deposits of ores and other minerals are highly desirable.
>
> ...
>
> Your committee believes that a special incentive for increased exploration for mineral deposits is desirable, especially in the case of taxpayers with limited financial resources."

The Committee's explanation is most interesting for its implicit admission that depletion allowances were an inadequate stimulus to exploration for minerals. Depletion was frequently defended on that ground. Of course, other reasons may also have entered into the decision. The political climate for legislation favorable to the mineral industry was excellent in the early 1950's, and the adoption of expensing may have been just another tax break. Congress was probably also influenced by the existence of the intangible drilling and development deduction for oil and gas taxpayers.[49]

In 1954, Congress amended the exploration expenditure deduction (§615) to allow up to $100,000 for four years. The next point of attack was the four year limitation. Critics pointed to the discrimination against smaller producers who were unable to benefit from the entire $100,000 allowance in one year.[50] In response to this problem, the four year limitation was eliminated in 1960.

Section 617, the provision that now governs all exploration expenditures, was adopted in 1966 as an option to the limited deduction (without recapture) offerred by §615. The Senate Report gave the following explanation for the new alternative:

> "For the many taxpayers who had already reached the $400,000 limit in exploration expenditures, the incentive to continue mining explorations was substantially reduced. Not only do they lose the tax advantage of the immediate write off of these exploration costs, but also in the case of exploration expenditures which prove unsuccessful they were likely to forego the recovery of these costs for almost an indefinite period." (Sen. Rep. No. 1377, 89th Congress, 2d Session).

The Report also noted that the inclusion of a recapture provision was necessary to avoid aggravating the problem created by giving taxpayers deductions from ordinary income for amounts subsequently taxed as capital gain.

The most recent amendment was made in 1969. The option of a limited deduction without recapture was eliminated for subsequent years. Section 617 now provides the only deduction for exploration expenditures.

D. CURRENT DEBATE

Recent hearings on the tax treatment of the mineral industries have given surprisingly little attention to the expensing provisions. Critics are most concerned by the "double benefit" problem. This situation could be remedied without changing the expensing deductions by an amendment requiring that any costs expensed be deducted as allowable depletion.[51]

The reason for the lack of significant opposition may be the similarity between Sections 616 and 617 and other provisions of the tax code allowing accelerated depreciation or amortization. The concept of delaying taxes to achieve desired social ends may be too well engrained to be challenged in the context of any one industry.

However, the same cost and benefit questions raised regarding depletion could also be asked of the expensing provisions. Assuming expensing does serve to facilitate desirable increases in mining exploration and development, the taxpayer is still entitled to ask whether the same benefits might be achieved through less expensive means.

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42. Senate Report No. 627. The Revenue Bill of 1943. p. 64.
43. See also Jenks, pp. 1743-44.
44. The description that follows is based on the accounts given by Ross, p. 1724; Jenks, pp. 1738-42; and Glassman, Part 11, pp. 1706-10, in General Tax Reform.
45. For examples, see Hambrick, in General Tax Reform, Part 9, pp. 1373-75.
46. The merits of these tax benefits are thoroughly debated in General Tax Reform, Part 11. See Glassman, pp. 1730-32; Jenks, pp. 1746-49; Musgrave, pp. 1756-58; and Stone, pp. 1838-41. Debate on these issues appears on pp. 1860-62 and 1876.
47. Agria[8], p. 90
48. Ibid.
49. This reasoning is supported by the Committee's explanation for

allowing expensing of development expenditures: "It is believed that the expenditures for the development of a mine...are essentially similar to those incurred after the production stage has been reached, and like those, should be treated as expenses relating to the production of the ore or minerals."

50. See Merten's, Chap. 24, pp. 309-310.

51. See Statement of J. Hambrick, in General Tax Reform Panel Discussions, p. 1371.